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HOLT'S  
DISEASES OF INFANCY  
AND CHILDHOOD



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# HOLT'S DISEASES OF INFANCY AND CHILDHOOD

A TEXTBOOK FOR THE USE OF  
STUDENTS AND PRACTITIONERS

BY THE LATE  
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*REVISED BY*

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*TENTH EDITION REVISED*

A59251

D. APPLETON-CENTURY COMPANY  
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NEW YORK LONDON

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## NOTE ON THE TENTH EDITION REVISED

The decision of the publishers to reprint "Diseases of Infancy and Childhood" has given us the opportunity to make a number of corrections. References have been added, numerous statements have been altered and here and there a paragraph has been rewritten in the endeavor, always an elusive one, to keep the text abreast of a rapidly growing body of pediatric knowledge.

L. E. H., JR.  
R. M.







## PREFACE TO THE TENTH EDITION

In undertaking the present work of revision the authors are fully aware of the difficulty of maintaining the standards set by their predecessors. It has been our aim to incorporate the newer facts and points of view in pediatrics without sacrificing the clear and concise style which has characterized the book in the past. In an age where deference to authority and adherence to tradition have been rapidly giving way to an attitude of scientific inquiry, we have deemed it appropriate to treat a number of topics in a less didactic manner than heretofore; and while we have not hesitated to express opinions upon debatable questions, we have attempted to present critically the evidence upon which they are based. The opinions expressed in these pages are wholly our own; we have, however, taken the liberty of retaining the first person in regard to the experiences of our predecessors. A bibliography has been added, which, however incomplete, should make the book of greater value for reference. In many instances more space has been devoted than in previous editions to the interpretation and pathogenesis of particular diseases, but we believe that this has been accomplished without losing sight of the main purpose of the book, which should be—as it has been in the past—eminently practical. In our opinion there are no short-cuts to practical therapy; intelligent treatment, whether it be rational or empirical, depends upon a thorough understanding of the nature of disease.

Extensive changes have been made in the present edition. The sections on nutrition and nutritional disorders, deficiency diseases, diseases of the blood and diseases of allergy have been completely rewritten; the same is true of much of the material on diseases of the nose and throat, the genito-urinary system and the nervous system. The list of rewritten articles includes those on premature infants, diabetes mellitus and, among the infectious diseases, tuberculosis, rheumatic fever and the common cold. New articles have been added on chemical relations in childhood, immunology in childhood, general considerations of allergy, serum disease, burns, lead poisoning, dwarfism, diseases of the parathyroids, xanthomatosis, lipoid cell pneumonia, rabies, smallpox, postinfectious encephalitis, erysipelas, typhus fever, tick-bite fever, tularemia, undulant fever and some of the less frequent diseases of the skin and of the nervous system.

It is a pleasure to acknowledge the assistance given by many of our colleagues in the preparation of the present volume. Dr. Frank R. Ford has borne the lion's share of the revision of the section on organic nervous diseases; he has rewritten entirely the articles on cerebral palsies of childhood and epidemic encephalitis and has contributed new articles on rabies, postinfectious encephalitis, Schilder's disease, tuberoze sclerosis and other topics. Dr. H. W. Josephs has collaborated in the section on diseases of the blood and has rewritten much of the article on diphtheria. A large part of the revision of the diseases of the skin has been done by Dr. P. G. Shipley, to whom we are indebted for several shorter articles on some of the



uncommon skin diseases and for the discussion of typhus and tick-bite fever. Dr. L. W. Ketron has also given assistance in the section on Diseases of the Skin. Our thanks are due to Dr. H. G. Guild for rewriting the articles on nephritis, to Dr. T. T. Burger for assistance in the article on syphilis and to Dr. E. M. Bridge for help in the preparation of the articles on burns and on epilepsy. The article on erysipelas was contributed by Dr. A. J. Schaffer; that on amyloidosis by Dr. L. Wilkins. Dr. T. C. Goodwin has written the articles on lipoid pneumonia and lead poisoning and with the aid of Dr. R. Harriss has prepared the index. Drs. F. B. Kindell and A. R. Rich have given us much helpful criticism in regard to questions of pathology and have rewritten some of the pathological descriptions. Dr. L. R. Polvogt has given us valuable criticisms in connection with the diseases of the nose, throat and ears, and assistance in the preparation of the illustrations of ear drums. Dr. M. F. Campbell has given us a number of helpful suggestions in regard to diseases of the genito-urinary tract, and Dr. L. Kanner has been kind enough to read and criticize the discussion of functional nervous diseases. Dr. D. J. McCune and Dr. L. Kajdi have given valuable assistance in the preparation of the bibliography. Many others, whom space forbids us to mention by name, have read one or another part of the manuscript and given us the benefit of their experience.

To Dr. Edwards A. Park we owe a very particular debt. He has read large parts of the manuscript and has been of great help to us, particularly in regard to nutritional disorders, tuberculosis, rickets and other bone diseases; moreover, he has most generously permitted us to use freely his own unpublished studies. He has himself rewritten the pathology of bone syphilis and portions of the article on meningococcus meningitis. But of even greater account than this material assistance has been the constant encouragement and inspiration which he has given us in our work.

The list of our acknowledgements would be incomplete without mention of our publishers. Messrs. D. Appleton and Company have been most coöperative in undertaking a complete resetting of the text, and have been more than patient in the face of repeated delays in the completion of the manuscript. They have improved the quality of the illustrations and have permitted us to introduce many new ones, including several plates in color.

L. EMMETT HOLT, JR.  
RUSTIN MCINTOSH



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## SECTION I

### *GENERAL CONSIDERATIONS*

## CHAPTER I

### HYGIENE AND GENERAL CARE OF INFANTS AND YOUNG CHILDREN

#### CARE OF THE NEWLY BORN CHILD

After ligature and section of the umbilical cord the infant should be wrapped in a soft blanket and either placed temporarily in a warm environment or given over immediately to the care of an attendant. The prophylactic instillation of an antiseptic into the eyes soon after delivery, following the recommendation of Credé, is now an almost universal practice; a drop or two of a 1 or 2 per cent solution of silver nitrate is left in each eye for two minutes before being washed out with boric acid solution. The vernix caseosa covering the infant's body is best removed with sterile absorbent cotton dipped in olive oil, sweet oil, or paraffin oil. The cord stump should be wrapped in a sterile gauze sponge wrung out in alcohol or dusted with a drying powder and held in place by a flannel binder. It is good practice at this time to examine the infant thoroughly for injuries received during delivery and congenital deformities and to observe the condition of the circulation and respiration. The prepuce of male infants should be retracted and any abnormalities noted.

After dressing, the child should be placed in his crib and covered with blankets, and if the temperature is subnormal, the feet cold, or the fingers and lips a little blue, he should be surrounded by hot-water bottles covered with flannel and placed near, but not in contact with, the body. The crib should be placed in a quiet room. The young infant should not occupy the same bed as the mother.

The cord should be kept dry and disturbed as little as possible until it falls off. Under ordinary circumstances the cord separates from the fourth to the tenth day, the average being the sixth day. The stump should then be covered with sterilized talcum or bismuth powder and a pad of sterile gauze about  $\frac{1}{4}$  inch thick and 2 inches square secured in position by the abdominal band. The pad should be continued until the umbilical wound has completely healed.

**Bathing.**—During the first few days of life the infant may be cleaned with oil and cotton, the full bath being deferred until after the cord has separated, not necessarily until the umbilical wound has healed. For the first few months the bath should be given at 98° F. in a warm room. The bath should be short and the body dried quickly, without too vigorous rubbing. The addition of salt to the bath is an



advantage where the skin is unusually delicate or excoriations are present. An approximately isotonic solution is obtained with one small handful of table salt to a gallon of water. By the sixth month the temperature of the bath for healthy infants may be lowered to 95° F., and by the end of the first year to 90° F. Healthy children of six months or older should be sponged or douched for a moment at the close of the tepid bath with water at 65° or 70° F. During childhood the warm bath is preferably given at night. In the morning a cold sponge bath, given before feeding, is desirable.

**Clothing.**—The clothing of infants should be light, warm, nonirritating to the skin, and loose enough to allow free motion of the extremities; bands should not be pinned so tightly about the trunk as to embarrass the respiratory movements. The details of dress should be dictated by the welfare of the infant, rather than by the vagaries of fashion. The essentials are the diaper and some garment like a shirt or band with which to hold it in place; for warmth other articles may be added either as actual clothing or as bedding. Wool is warmer than cotton or rayon. Closely knitted goods are warmer than woven goods and allow more expansion to keep pace with growth. After the first three or four weeks of life, healthy infants tolerate a cold environment exceptionally well, often better than adults who have become the victims of ingrained habit. The common mistake is that of overclothing. The overclothed child is likely to be fretful and to perspire. Evidences of inadequate clothing are less definite. One cannot assume that an infant is underclothed because his hands and feet are cold, since many normal infants habitually show this. The infant suffering from mild chilling is likely also to be fretful; his muscular activity is increased; he may be cyanotic. With severe chilling his reactions are less vigorous and his body temperature may be subnormal.

In newly born infants an abdominal binder is used to hold the umbilical dressing in place; with the healing of the umbilical wound the necessity for it ceases. Its usefulness in the prevention of umbilical hernia is highly problematical. It cannot be regarded as a significant item in the prevention of colic. As a means of adding warmth in the case of poorly nourished infants it is, on account of the difficulty of keeping it in place, less serviceable than other articles of clothing.

The changes of clothing in different seasons will depend entirely upon the climate. In the hottest weather it may be advisable to remove all clothing except the diaper.

The night clothing of infants may be identical with that worn during the day. The night clothing for older children should consist of a union suit with waist and trousers, and in some cases with feet, if there is a tendency to get outside the coverings. The usual mistake is to overload all children, but especially infants, with covering at night. This is an explanation of much of the restless sleep which is seen, particularly in delicate children.

**Care of the Eyes.**—If, during the first few days of life, the eyes are the seat of a mild conjunctivitis as a result of the instillation of antiseptics, they may be cleansed twice a day with a saturated solution of boric acid. They should be protected from too strong light during early infancy, less on account of the possibility of harm to the eye itself, for this is almost negligible, than because strong light appears at times to be a painful stimulus to the infant. Overzealous protection



from sunlight has in the past probably played a large part in the development of rickets.

**Care of the Nose, Mouth and Teeth.**—The infant's nose does not ordinarily require attention, but if necessary it may be cleansed each day at the time of the bath with small cotton swabs moistened in mineral oil. The mouth of the newly born infant requires no cleansing; it should, however, be carefully examined once a day for the presence of lesions.

The primary teeth as well as those of the permanent set should receive daily attention. Too often they are neglected altogether. Dirty teeth are likely sooner or later to become carious; and carious teeth, besides being a cause of bad breath and pain, are a constant menace to the health of the child, since they are frequently the cause of severe infections. Such teeth should either be filled or removed. The use of a small tooth brush with soft bristles and of a bland dentifrice free from grit may with advantage be commenced when the upper incisors have erupted.

**Care of the Skin.**—The skin of a young infant is exceedingly delicate, and excoriations, intertrigo and eczema are of very common occurrence. These conditions are much easier of prevention than of cure. The first essential in the care of the skin is cleanliness, and this must be secured without the use of strongly alkaline soaps or too much rubbing. Diapers should be removed as soon as soiled or wet, and it is a good practice, particularly in the case of young infants, to apply a small amount of oil to the entire diaper area at the time of changing. The skin of many infants requires nothing further than careful drying after the bath; others, particularly very fat infants, benefit by the application of a small amount of oil or lanolin or of some bland absorbent powder in the folds of the skin. If plain water produces an undue amount of irritation, salt baths should be employed.

**Care of the Genital Organs.**—The female genitals need but little attention in young children, except as to cleanliness. This is more often neglected in older children than in infants.

In males the prepuce should receive attention during the first few weeks of life. If the foreskin is very long and the preputial orifice small, circumcision should be done. If it is not long, but is only adherent, these adhesions should be broken up, the parts thoroughly cleaned and the foreskin retracted daily until there is no disposition to a recurrence of the adhesions. These operations will be discussed more at length in a subsequent chapter. The only thing to be emphasized in the present connection is that the prepuce should receive proper attention in early infancy, since this can now be done with less pain and discomfort to the child, and better results can be obtained. If this matter is neglected during infancy, it is apt to be overlooked.

**Protective Inoculations.**—Immunization against diphtheria and smallpox, although considered elsewhere, should be mentioned in this connection as among the things requiring the physician's attention during the first months of life.

**Training to Proper Control of Rectum and Bladder.**—It is surprising to see what can be accomplished by intelligent efforts at training in these particulars. An infant can often be trained at three months to have his movements from the bowels when placed upon a small chamber. The infant should be put upon the chamber soon after his feeding. It is important that young children should be



trained to regular habits regarding evacuations from the bowels. Much of course will depend upon the food and the digestion; but habit is a very large factor in the case.

The training of the bladder is not quite so important, but the proper education of this organ adds much to the comfort of the child and the ease with which he is cared for. Before the end of the first year many intelligent children can be trained to indicate a desire to empty the bladder. Before he has reached the age of three years a healthy child will usually go from 10 P.M. until morning without emptying the bladder. The annoyance and discomfort from the neglect of early training in this particular are very great.

Night feeding is responsible for much of the difficulty experienced in training children to hold the urine during the night.

**General Hygiene of the Nervous System.**—The normal development of the nervous system demands quiet, peaceful surroundings and freedom from excitement and undue stimulation. The practice of playing with infants and exciting them by sights, sounds and motions until they shriek with apparent delight is often harmful and should be condemned. There can be no doubt that automobile riding, radios and moving pictures are in part responsible for the increasing frequency of functional nervous disorders among children. It has been claimed by a number of psychologists that the personality of an individual—his emotional reactions and habits—is determined very largely by his environment and training in the first few years of life. Peculiar traits of character are attributed to mental injuries received at this time. The argument is supported by the fact that the brain grows more during the first two years than during the rest of life. We are not inclined to accept this extreme view of the case. Although a proper emotional environment and early habit training are greatly to be desired, for the benefit both of the child himself and of those who care for him, it appears that the influence of the early environment is largely temporary. It is surprising how rapidly a child will respond to a good environment if he is under four or five years old, even if his early surroundings and training have been of the worst sort. After this age, emotional and intellectual habits become increasingly difficult to change; a bad environment is more likely to leave permanent scars.

**Sleep.**—The sleep of the newly born infant is profound for the first two or three days and under normal conditions almost continuous. In the case of prolonged or tedious labor, or where from any cause undue compression has been exerted upon the head, it may approach the condition of semicoma for twenty-four or forty-eight hours. This may be so deep as to excite apprehension of serious brain lesions. If, however, there are associated with it no generalized convulsions or myoclonic twitchings and no rigidity, this early stupor usually passes away on the second or third day.

The sleep of early infancy is quiet and peaceful, but not very deep after the first month. After the third year the heavy sleep of childhood is commonly seen. A healthy infant during the first few weeks sleeps from twenty to twenty-two hours out of the twenty-four, waking only from hunger, discomfort, or pain. During the first six months a healthy infant will usually sleep from sixteen to eighteen hours a day, the waking periods being only from half an hour to two



hours long. At the age of one year most infants sleep from fourteen to fifteen hours; from eleven to twelve hours at night, and two or three hours during the day, usually in two naps. When two years old usually thirteen to fourteen hours' sleep are taken; eleven or twelve hours at night and one or two hours during the day, generally in a single nap. At the age of four years children require from eleven to twelve hours' sleep. It is always desirable, and in most cases with regularity it is possible, to keep up the daily nap until children are six years old. From six to ten years the amount of sleep required is ten or eleven hours, and from twelve to sixteen years nine hours should be the minimum. These figures are, however, not to be considered as universally applicable, for there is a wide range in the requirements of individuals.

Training in proper habits of sleep should be begun at birth. From the outset an infant should be accustomed to being put into his crib while awake and to go to sleep of his own accord. Rocking and all other habits of this sort are unnecessary and even harmful. Infants will from the start tolerate a moderate amount of noise without waking; it is therefore unnecessary to modify the customary noises of the household routine in their favor.

The periods of sleep in young infants are usually from two to three hours long, with the exception of once or twice in the twenty-four hours, when a long sleep of five or six hours occurs. The purpose of training is to have the child take this long sleep at night. The habit of regular sleep is best established by wakening the infant regularly every three or four hours during the day for feeding, and allowing him to sleep as long as possible during the night. This training goes hand-in-hand with regular habits of feeding. Such habits are easily formed if the plan be systematically followed from the outset.

By the third month all feeding between 10 P.M. and 6 A.M. should be discontinued. If this is done most infants can be trained by this time to sleep all night. Regularity in sleep and feeding not only makes the care of young infants very much easier, but is of a good deal of importance for the health of the child. The causes of disturbed or irregular sleep in young infants are mainly two—hunger and indigestion. In nursing infants it is usually the former.

**Exercise.**—This is no less important in infancy than in later childhood. An infant gets his exercise in the lusty cry which follows the cool sponge of the bath, in kicking his legs about, waving his arms, etc. By these means pulmonary expansion and muscular development are increased and the general nutrition promoted. An infant's clothing should be such as not to interfere with his exercise. Infants who are old enough to creep or stand usually take sufficient exercise unless they are restrained. At this age they should be allowed to do what they are eager to do. Every facility should be afforded for using their muscles. Exercise may be encouraged by placing upon the floor in a warm room a mattress or a thick pad or quilt, and allowing the infant to roll and tumble upon it at will. A large bed may answer the same purpose.

In older children every form of out-of-door exercise should be encouraged. Up to the eleventh year no difference need be made in the exercise of the two sexes. Companionship is a necessity. Children brought up alone are at a great disadvantage in this respect, and are not likely to get as much exercise as they



require. The amount of exercise allowed delicate children should be regulated with some degree of care. It may be carried to the point of moderate muscular fatigue, but never to muscular exhaustion. The latter is particularly likely to be the case in competitive games.

**Airing.**—In summer there can be no possible objection to a young infant's being allowed out of doors at the end of the first week. At other seasons this will depend upon the weather conditions. During the outing his head should be protected from the wind. The duration of the outing at first should be only fifteen or twenty minutes, the time being rapidly lengthened to two or three hours. The child should be gradually accustomed to changes of temperature in the room by opening wide the windows for a few minutes each day even before he is taken out of doors, the child being dressed meanwhile as for an outing. In the case of children born late in the fall or in the winter this means of giving fresh air may be advantageously begun at one month and followed throughout the first winter. It is only necessary in all such cases that the changes be made gradually both as to the length of the airing and as to the temperature. It is a matter of importance that every infant be furnished an abundance of fresh air in winter as well as in summer.

When four or five months old, there is no reason why a healthy child should not go out of doors and sleep out of doors in pleasant weather if the temperature is not below 20° F. The days of all others when infants and very young children should not be out of doors are when there are high winds and severe storms. Delicate infants must of course be more carefully guarded during the cold season. With most of these the plan of house-airing is all that should be attempted.

**Sunlight.**—Sunlight is essential for all infants. Its chief benefit lies in the ultraviolet rays which are normally present in abundance. Ultraviolet rays have a very striking effect in preventing and in curing rickets and tetany. It is these rays which cause pigmentation of the skin. It is possible that they exercise, in addition, some beneficial effects on the general health. The practice of giving sunbaths should by all means be encouraged.

Since ultraviolet rays do not penetrate ordinary window glass or clothing appreciably, direct exposure is usually necessary. Dust and moisture in the air greatly interfere with the passage of these rays, as does to a certain extent the atmosphere itself. Hence, rays coming obliquely when the sun is near the horizon are far less effective than when it is overhead. In winter and at certain latitudes sunlight may be very poor in this respect.

When the climate is such that direct sunlight cannot be relied on, some substitute should be adopted. A number of lamps are available which generate ultraviolet rays. The specific protective and curative action against rickets and tetany can be accomplished equally well by giving cod liver oil or some other preparation containing vitamin D by mouth, a matter which is more fully discussed in connection with rickets.

**Nursery.**—This should be a sunny and well-ventilated room. Sunlight is absolutely indispensable. Sunny rooms always contain less organic matter and less humidity.

The temperature of the room during the day should not be over 70° F. At



night for the first few weeks the temperature should not be allowed to fall below 65° F. After two months the night temperature may fall to 60° or even 50° F.

Free ventilation without draughts is a necessity. While the child is absent from the room the windows should be widely opened and free airing of the nursery accomplished. The room should always be thoroughly aired at night before the child is put to bed. After the first year the window may be open, unless the outside temperature is below 20° F. If the window is open the door of the nursery should be closed, so that currents of air may be avoided.

The child, whenever it is possible, should have a separate bed; and so should the newly born infant, in order to avoid the danger of too frequent night nursing, which is injurious alike to mother and child. Separate beds for older children will prevent the spread of many forms of infection. The crib for infants should be one which does not rock. The mattress should be of hair and quite firm. The pillow is not a necessity.

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## CHAPTER II

### THE CARE OF PREMATURE AND DELICATE INFANTS

Infants born before term and some exceedingly delicate ones who are born at full term require particular care. Their vitality is so feeble that if handled in the ordinary way they survive at most but a few weeks. The chief indication that such care is necessary is the weight of the child. Any child weighing less than 2500 grams ( $5\frac{1}{2}$  pounds), or whose body length is less than 48 centimeters (19 inches), belongs in this group, which includes the majority of twins born at term.

The clinical picture presented by these cases is quite characteristic. The body is limp; the skin very soft and delicate, almost transparent, and often covered with a considerable growth of lanugo; the nails may not extend to the ends of the fingers; subcutaneous fat is almost absent. The cry is a low, feeble whine not unlike the mew of a kitten; the respiratory movements are extremely irregular, sometimes scarcely perceptible for several seconds. The general appearance is one of torpor; the movements of the extremities are infrequent and never vigorous. The muscles of the mouth, cheek and tongue may lack the requisite force for sucking, and even deglutition is likely to be difficult and prolonged. All the symptoms vary greatly with the degree of prematurity and the size of the infant.

In the management of these cases there are three problems to be solved—to maintain the body temperature, to nourish the infant and to prevent infection.

**Regulation of Body Temperature.**—The premature infant suffers from two handicaps. His heat-producing power is inadequate, and his temperature therefore falls quickly below normal unless artificial heat is supplied. His ability to dissipate excess heat by perspiration and increased respiration is also imperfectly developed, and it is therefore equally important to protect him against overheating. Without constant supervision, particularly in the first few days of life, the temperature may show extraordinary variations, falling 4 or 5 degrees below normal or rising as much above it. We once saw a fluctuation of  $13^{\circ}$  F. within a few hours from such causes.

The inability of these infants to produce heat is due in part to the absence of voluntary muscular movements, and partly to an abnormally low level of body oxidations. Talbot and Sisson have found that such infants usually have a low basal metabolism.

Effective measures for maintaining the temperature should be started immediately after birth, since survival depends on this perhaps more than on any other single factor. The prognosis of premature infants born in a hospital has been shown to be better than of those born at home and subsequently brought to a hospital for care, since the latter arrive almost without exception with a markedly subnormal temperature.



To prevent loss of heat, the body should be immediately oiled and wrapped in cotton, with only the face exposed. The usual diaper may be replaced by a pad of gauze and absorbent cotton. The child may then be wrapped in blankets. These preliminary measures should be carried out in a warm room.

Artificial heat may be applied in several ways. One of the simplest methods is to place the child, wrapped in blankets and surrounded by hot water bottles, in a clothes basket or bassinet with protected sides. Electric heating pads have been employed as a source of heat, but they occasionally get out of order and have been known to cause severe burns.

Individual incubators have been successfully used in many clinics. They are scarcely practical, however, except in institutions. They are expensive and require expert mechanical advice, but do to a certain extent offer an added protection against infection.

In our opinion the ideal arrangement for the care of premature infants is a warm room specially equipped for that purpose. The temperature should be maintained between 80° and 90° F. The cribs should be walled off by glass partitions so as to diminish the chances of infection. The respiratory exchange of these infants is so small that ventilation is scarcely a problem. It is a common observation that these infants thrive better if provision is made for securing adequate, and preferably constant, humidity; for this purpose a shallow evaporating pan filled with water may be used. Such a room possesses the advantages of an incubator with few of its drawbacks.

Extreme fluctuations of temperature are seldom seen after the first few days of life. It is advisable to take the temperature every four hours until a reasonable degree of stabilization is obtained; after this, twice a day is usually sufficient. If the rectal temperature remains between 98° and 100° F. one should be content. The rapidity with which thermal control is secured is of some prognostic significance.

The handling of these infants should be reduced to a minimum. Until they are strong enough to take the breast, they should be fed without being removed from the crib. Some freedom of the limbs should, however, be permitted and the position changed from time to time. In place of bathing, the body may be oiled and fresh cotton applied every other day.

**Metabolism.**—The metabolism of these infants presents several peculiarities. The basal metabolism is often below the normal and the caloric requirements for muscular activity are minimal, yet these are compensated for by increased demands for growth and by an excessive loss in the excreta representing poor absorption from the intestine. The result is that the total caloric requirements of the premature are as high or higher than those of the normal infant. In our experience few of these infants will gain weight on less than 125 calories per kilogram; with others it may be necessary to give as much as 175 calories.

The excessive requirements for growth are borne out by the observations of Rubner and Langstein, who found that, of the calories absorbed in excess of basal requirements, 80 to 94 per cent were utilized for growth in contrast to 56 per cent for the normal breast-fed infant. Nitrogen retention was relatively higher than with normal infants. The same observers have demonstrated an impaired absorp-



tion of foodstuffs from the intestine, particularly striking in the case of fat. In spite of this, however, it would appear that the storage of fat by these infants actually exceeds that of the normal child, a fact which implies that considerable body fat is formed from carbohydrate. The carbohydrate metabolism of the premature infant has recently been studied by Van Creveld, who has found an abnormally low level for the fasting blood sugar (below 0.06 per cent). Following the administration of dextrose, the rise in the sugar level is sustained for an unusual length of time. It seems possible that the explanation of this phenomenon lies in a patent ductus venosus, which permits a considerable fraction of the portal blood to reach the vena cava without passing through the liver. The findings in experimental animals with an Eck fistula have been quite similar.

**Feeding.**—The foregoing data find a limited practical application. The high nitrogen retention and the low blood protein suggest that these infants may need relatively more protein than the full-term infant. It may also be desirable to give a fat that is more readily assimilated than butter fat. However, although breast milk is no longer regarded as a practical necessity for premature infants, the fact remains that it is a particularly valuable food for these patients, and every effort should therefore be made to secure it for them. The premature infant can seldom nurse effectively; hence the mother's milk supply is likely to fail unless the breasts are pumped regularly. The electric pump is the most effective means of doing this, but in many cases manual expression is entirely satisfactory. If the mother cannot supply milk, recourse to a wet-nurse may be necessary; breast milk can be purchased in a number of American cities.

Infants born at eight months and those weighing 5 pounds or thereabouts can usually be made to take the breast after the first few days. Few below this age or weight will do so. Some will suck from a bottle, but the majority must be fed by other means. A medicine dropper may be used or a larger feeder made upon the same principles; the smallest and feeblest, however, must be fed by gavage. The food should be given slowly; if rapidly, some is likely to be regurgitated, and this may produce attacks of asphyxia or even an aspiration pneumonia. The quantity of food and frequency of feeding will depend upon the size and age of the child.

During the first week of life the food should be gradually increased until the intake has been increased to approximately 100 calories per kilogram. Until this point has been reached, it cannot be considered that fluid requirements have been met by milk alone; hence, additional water will be needed during this period, as indicated in Table I.

The number of feedings given is a matter of secondary importance. With many infants six feedings a day with a four-hour interval succeeds best; with some a shorter interval is preferable. The plan of less frequent feedings has the advantage of requiring less handling and disturbance of the child; besides, it simplifies the care of these infants.

Although a few premature infants will thrive and gain steadily on an intake of 100 calories per kilogram, the majority require more than this. If at the end of the second week there is no tendency to gain, the intake should be cautiously increased. It may be necessary eventually to give as much as 150 or 200 calories



per kilogram per day. It is a safe rule, however, that the lowest intake which will insure a satisfactory gain is the most suitable in the long run.

Owing to the small capacity of the stomach of the premature infant, a concentrated food is desirable when a high intake is to be given. This is always indicated when the food tends to cause regurgitation, gastric dilatation or cyanosis, and as a general rule when more than 125 calories per kilogram are prescribed. The food may be concentrated by the addition of cane sugar (5 to 10 per cent). Such feedings are well borne, but the prolonged use of such a high carbohydrate diet should

TABLE I  
FEEDINGS (BREAST MILK) FOR PREMATURE INFANTS DURING THE FIRST WEEK

Weight	Daily Quantity of Feeding, Ounces					
	1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day
2 lbs. (1000 gms.)	Milk 2 Water 2½	Milk 2½ Water 2	Milk 3 Water 1½	Milk 3½ Water 1	Milk 4 Water ½	Milk 4½ Water 0
3 lbs. (1500 gms.)	Milk 3½ Water 3½	Milk 4 Water 3	Milk 4½ Water 2½	Milk 5 Water 1½	Milk 6 Water 1	Milk 7 Water 0
4 lbs. (2000 gms.)	Milk 4½ Water 4	Milk 5 Water 4	Milk 6 Water 3	Milk 7 Water 2	Milk 8 Water 1	Milk 9 Water 0
5 lbs. (2500 gms.)	Milk 6 Water 5	Milk 7 Water 4	Milk 8 Water 3	Milk 9 Water 2	Milk 10 Water 1	Milk 11 Water 0

be avoided, since the protein and mineral requirements are likely to suffer. A more logical procedure, and one that can be continued indefinitely, is to reinforce breast milk with cow's milk curd. Our own observations with this feeding confirm those of Langer that fewer calories are required to produce gain in weight than is the case with high carbohydrate feedings. If diarrhea develops in a breast-fed premature infant, it is advisable to reduce the quantity of the food and to replace one or two feedings with buttermilk.

In the artificial feeding of premature infants almost all the common feedings have been used at one time or another with some success. In our opinion dried milk, evaporated milk and acid milks offer a distinct advantage, because of the fine curds produced. Carbohydrates may be added in quantities similar to those which are used with normal infants. The feeding may be concentrated, when desired, by reducing the amount of water, or by adding curd (1½ per cent) or powdered protein milk, rather than by further additions of carbohydrate. In a number of our patients we have found that fat assimilation and gain in weight were definitely improved by the substitution of homogenized olive oil for the butter fat of the feeding. With these vegetable oils particular attention should be given to the infant's requirements of vitamines A and D.

The special precautions given in regard to the care and feeding of premature infants should be continued until the normal birth weight has been reached.

**Prevention of Infection.**—It is often stated that the premature infant is more susceptible to infections than a full term child or an adult, although convincing proof of this assertion has not been presented. There can be no question,



however, that the consequences of infections in these patients are so serious that no effort should be spared to prevent them. Even such a benign infection as a simple rhinopharyngitis or an impetigo may initiate a decline which continues relentlessly to a fatal termination. The responsibility for the transmission of infection rests directly on those who come in contact with the patient: they should pay particular attention to the cleanliness of hands, arms, uniforms; they should wear gauze masks at all times when in the same room with the patient; and during acute respiratory infections of even minor degree they should be relieved of duty.

**Development.**—It is somewhat uncommon for premature infants to commence to gain within a few days after birth. More often the weight curve is nearly level for a week or two, or even longer, before showing a steady rise. When growth is well established, progress is usually rapid and satisfactory unless interrupted by infections or digestive disturbances. The rate of growth, in fact, is such that the birth weight may be doubled at two months and quadrupled or more at one year. By the end of the first year many have compensated for their early handicap and are as large and vigorous as other infants. There seems to be no lasting effect produced by prematurity alone.

**Complications.**—The high mortality of these immature infants during the first twenty-four or forty-eight hours is attributed by most authors to pathologic physiology, as yet imperfectly understood, connected with the transition to extra-uterine life. Many of the deaths at this age, however, are the result of internal hemorrhage, particularly in the brain, to which infants at this stage of fetal development are peculiarly liable owing to the structural immaturity and consequent fragility of their blood vessels.

Atelectasis of some degree is an almost constant occurrence, since the feeble cry of these infants is insufficient to expand the lungs properly. With this is associated a susceptibility to attacks of cyanosis, often accompanied by apnea. These can often be controlled by mechanical stimulation of the skin, as by pinching. Still more effective is the use of oxygen containing 7 per cent carbon dioxide, as recommended by Yandell Henderson. The symptoms of atelectasis and cerebral hemorrhage are similar; their differential diagnosis is discussed elsewhere.

Physiological icterus, common in the full term infant, develops almost invariably in the premature, and is likely to be more pronounced and to last for a longer time. The mechanism is discussed on page 78. In the premature infant, blood islands are present at birth both in the liver and spleen. Both are obliterated shortly after birth, and as a result of the abnormally great blood destruction the degree of jaundice is greater.

Anemia develops with great frequency in these infants. The explanation usually given is that the storage of iron in the liver normally occurring in the last month of fetal life has not taken place. This storage is believed to supply the child with iron throughout the period of lactation, during which his diet is very inadequate as far as that element is concerned. It may be that in addition the premature infant has an impaired capacity to absorb ingested iron. The administration of inorganic iron is often effective both in preventing and in curing this anemia. On this account it should be given as a routine to all premature infants as early as the second week. We employ a solution of ferric ammonium citrate, which may be added directly



to the milk. The daily dose per kilogram of body weight is 10 to 25 milligrams of iron.<sup>1</sup>

Premature infants are highly susceptible to rickets; for this there are several causes. Calcification proceeds rapidly in late fetal life, hence the bones of the premature at birth are relatively poor in lime salts and he starts life with a handicap which must be overcome after birth. In the face of this high requirement of calcium and phosphorus, he is usually fed on breast milk, which perhaps does not contain enough of these minerals for such a rapidly growing subject. Lastly, he absorbs calcium and phosphorus with difficulty, a fact which is probably related to deficient absorption of vitamin D; the premature infant is known to absorb unsaponifiable lipid matter poorly.

Many premature infants show bone deformities and evidences of bone softening such as *craniotabes*<sup>2</sup> which do not appear to be rachitic in origin. Pathologically there is merely an osteoporosis, which may be defined as a condition in which the cortex and individual trabeculae are homogeneously but less densely calcified; the trabeculae are often slender and fewer than normal in number. Some degree of osteoporosis is always present in true rickets, but in these infants osteoporosis may and commonly does occur alone. It may be quite impossible to establish the presence of rickets from clinical data. The roentgen ray, and particularly the blood chemical changes, will usually make a differentiation possible, for both the calcium and the inorganic phosphorus of the serum are normal in uncomplicated osteoporosis. Since such studies are not ordinarily made with premature infants and because of the uncertainty of the clinical diagnosis, it is advisable to give anti-rachitic treatment to all premature infants. For reasons we have discussed above, the usual dosage is often ineffective and four or five times as much is required. The excessive quantity of cod liver oil called for is more than likely to upset the digestion, and on this account ultraviolet radiation or preparations of ergosterol should be substituted. Viosterol may be given in doses up to 20 drops a day without harmful effect.

Rapid growth of the brain as compared with that of the skull leads to an enlargement of the head with separation of the sutures. The eyes are prominent and are directed downwards so that a continuous line of sclera appears above the cornea. This condition is found with increasing frequency the smaller the infant at birth. It becomes apparent by the second month and is most noticeable by the sixth or eighth month, after which it tends to disappear. It is often possible to make a retrospective diagnosis of prematurity from the facies as late as the third year. The condition has been termed *pseudohydrocephalus* or *megacephalus*; the capacity of the ventricles is not increased. A genuine hydrocephalus may occur as a result of hemorrhage at the base of the brain, but this is a relatively infrequent occurrence and does not tend to disappear spontaneously.

Delayed dentition is exceedingly common, the first tooth appearing sometimes only after the first year of life. Premature infants seem particularly susceptible to dental caries and defective occlusion; in this respect, however, much can probably be done in the way of prophylaxis by careful attention to mineral metabolism.

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<sup>1</sup> In a 10 per cent solution of ferric ammonium citrate, 1 c.c. is equivalent to 25 milligrams of iron.

<sup>2</sup> The *craniotabes* present in these infants is often spoken of as "physiological *craniotabes*."



Owing to the relatively high incidence of cerebral hemorrhage, already referred to, the occurrence of Little’s disease and of mental inferiority is higher among premature infants than in a similar group of full term infants. Since the recognition of these disorders is often impossible for several weeks or even months after birth, the mental prognosis must for some time be guarded. In a series of 598 cases followed for a sufficient interval to permit a definitive diagnosis in this respect, Dollinger found 3.1 per cent of cases of Little’s disease and 7.4 per cent feeble-minded. Among 196 prematures who reached school age and were subjected to Binet-Simon intelligence tests, Looft found 8.7 per cent inferior; he pointed out, however, that retardation up to the age of four years did not preclude an ultimately good prognosis.

Since syphilis in the mother is one of the common causes of premature birth, the incidence of congenital syphilis in these infants is relatively high; and here the prognosis for life is particularly poor, especially in the first few days after birth.

**Prognosis.**—The results will depend in large measure upon the size and vigor of the child, and the promptness with which proper care, especially artificial heat, is instituted. The nearer an infant approaches the full term measurements, the better is the outlook. Even under the best circumstances few infants survive whose birth weight is less than 2 pounds.<sup>3</sup>

Table II gives statistics of survival from various sources.

TABLE II  
PERCENTAGE SURVIVAL OF PREMATURE INFANTS

Fetal Age at Birth, Months	Potel	Pfaundler	Tarnier		Blackfan and Yaglou	
			Without Incubators	With Incubators	Unconditioned Nursery	Air conditioned Nursery
6 .....		5	0.0	16.0	28.6	41.2
6½ .....	19.6	18	29.5	36.6	50.0	42.9
7 .....	41.9	37	39.0	49.8	42.8	56.1
7½ .....	69.9	58	54.0	77.0	46.2	57.6
8 .....	64.5	80	78.0	88.8	61.8	68.9
8½ .....			88.0	96.0		

Prenatal conditions appear to exercise an important influence in prognosis. The high mortality in congenital syphilis has already been mentioned. Quite apart from congenital disease, however, it would seem that illness of the mother makes the prognosis less favorable. Pfaundler reports that of 100 infants born of healthy mothers, 63 survived the first year, while of an equal number born during the mother’s illness only 18 survived this period. In a smaller series, Lorey records a mortality in the first year of 21 per cent in infants born after induced labor, as opposed to a mortality of 82 per cent when labor was brought on by maternal illness.

<sup>3</sup> Finkelstein has set as limits for even a fair outlook an intra-uterine age of twenty-eight weeks, a body weight of 1000 grams (2 pounds, 4 ounces), a length of 34 centimeters (13.4 inches), head circumference 26.5 to 27 centimeters (10.3 inches), and chest measurement of 22.5 to 23 centimeters (9.0 inches).



The effect of the initial chilling on mortality is shown in Table III computed from data presented by Hess and Chamberlain:

TABLE III  
MORTALITY OF PREMATURE INFANTS WITH NORMAL AND SUBNORMAL  
ADMISSION TEMPERATURES \*

Birth Weight	Admission Temperature of 96° F. or Less			Admission Temperature of 97°-99° F.		
	Total	Died	Mortality, Per Cent	Total	Died	Mortality, Per Cent
Under 1000 grams.....	16	16	100	3	3	100
1000-2000 grams .....	90	56	62	80	20	25
2000-3000 grams .....	9	7	78	41	8	20

\* From data of Hess and Chamberlain.

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# CHAPTER III

## GROWTH AND DEVELOPMENT OF THE BODY

In the young, growth is a manifestation of life; it is exhibited by every normal individual. The factors which govern normal development are as yet very incompletely understood. Growth is greatly modified by intrinsic properties of the individual, such as the balance between the glands of internal secretion. It is doubtless here that heredity plays an important part. The influence of diet is discussed in the section on nutrition. Without certain essential food constituents—amino-acids and vitamins—growth ceases. A proper balance of all foodstuffs, inorganic as well as organic, is required for normal growth. Environmental factors, such as radiant energy, play a part which has only recently been appreciated.

Since nearly every form of acute or chronic disease impairs growth to some extent, it follows that regular growth is perhaps the best measure of health we possess. It is of the utmost importance that accurate observations upon growth and development be made during infancy and childhood. Such observations make possible the early detection and arrest of many diseases and disorders of nutrition; they should be made a part of the routine physical examination of every child, for it is only by familiarity with the normal that the detection of the abnormal becomes easy.

### WEIGHT

The weight of the infant is the best means we have to measure his nutrition. It is as valuable a guide to the physician in infant feeding as is the temperature in a case of continued fever. Although the weight is not to be taken as the only guide to the child's condition, it is of such importance that we cannot afford to disregard it during the first two years. It is of great advantage to keep up regular observations during childhood.

Weekly weighing should be done for the first six months, biweekly for the rest of the first year, and monthly during the second year. Delicate children should be weighed even more frequently. Spring scales are not reliable.

**Weight at Birth.**—The following figures are from consecutive cases taken in nearly equal proportion from the records of the New York Nursery and Child's Hospital, the Sloane Hospital, and the New York Infant Asylum, and include only full term children:

	<i>Average Weight</i>
568 females .....	7.17 lbs. (3260 grams)
590 males .....	7.48 lbs. (3400 grams)
<hr/> 1,158 infants .....	7.33 lbs. (3330 grams)

**Weight Curve during the First Few Weeks.**—We have made observations upon 100 healthy, nursing infants, 50 males and 50 females, at the Nursery and

Child's Hospital. The children were weighed daily during the period of observation. The average weight at birth was 7.1 pounds. The composite curve shows a very marked loss of weight on the first day and a slight loss on the second day, the lowest point being touched at the beginning of the third day; but from this time there was a steady gain. The average initial loss in these cases was 10 ounces, being in each sex exactly 11 per cent of the body weight. In 835 cases, including those above mentioned, the average loss was 9½ ounces. The loss of the first days represents an excess of tissue waste over the nutriment derived from the breasts. After the third day, coincident with an abundant secretion of milk, there is a steady, daily increase in weight. The birth weight is normally regained about the tenth day.<sup>1</sup> The most frequent deviation from the normal curve consists in a continued loss or stationary weight after the third day. This is most frequently due to an inadequate milk supply; it may be due to acute illness, or to a disturbance of nutrition from improper food.

**Weight Curve of the First Year.**—The accompanying weight curve (Fig. 1) is made up from complete charts of about two hundred healthy nursing infants who were thriving and weighed every week, and the incomplete charts of about

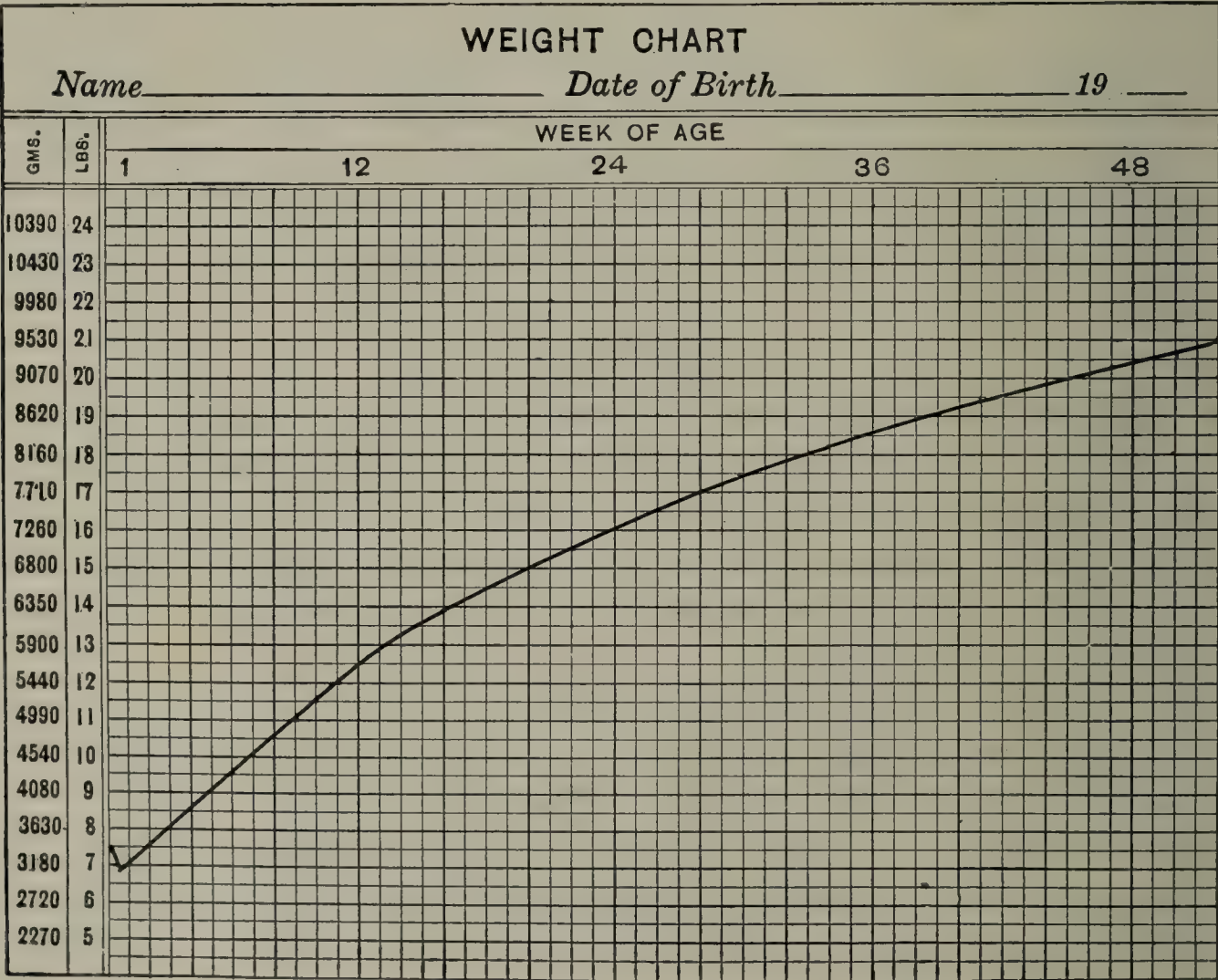


FIG. 1.—WEIGHT CURVE OF THE FIRST YEAR.

seven hundred other infants. There are represented about thirty thousand observations on children under one year. The most rapid increase is during the first three months. It is slowest from the sixth to the ninth month. This curve shows

<sup>1</sup> The initial loss of weight can often be greatly diminished or entirely prevented by giving an adequate amount of food from birth onward. With normal infants there is no advantage in so doing, but in the case of infants who are below the normal weight and particularly with premature infants it may be desirable to prevent this loss of weight.



the average rate of gain. It is not to be regarded as a normal line, like that of a temperature chart, but as an average line. An infant who at birth is above the average may keep this distance above the line for the whole year; another, weighing less than the average, may continue below it. Girls throughout the year are on the average half a pound lighter than boys. No single child exactly follows the line all the way, but it is surprising how close to it many come.

The curve of artificially fed infants who are healthy and properly fed does not differ greatly from that of breast-fed infants. With the latter there is usually a more rapid gain during the early months, and a slower gain during the later months, this being most often incident to weaning. A nursing infant therefore usually weighs more at six months, but may weigh no more at twelve months than one who is artificially fed.

During the first year a healthy child nearly trebles his weight. Perfect health is consistent only with regular gain in weight. The gain may not always be rapid but unless it is steady something is wrong; usually it is the food or the method of feeding. One should not be satisfied during the first half year unless the weekly gain is at least five or six ounces. During the second half year the average weekly gain is only about half as much. Certain infants fed upon condensed milk or foods composed largely of carbohydrates may show rapid gain in weight without other evidence of healthy nutrition.

**Weight of Older Children.**—Too little importance has been attached to the record of weight of older children; yet such a record during the entire period of growth represents the progress in health, quite as accurately as during infancy. After infancy the progress in weight is much less regular, and it is influenced by many conditions besides the food and feeding, *viz.*: the amount of activity, rest and sleep, the season, the general hygiene, minor illnesses, etc. But progress in weight is quite as significant as during infancy. In the early years girls are a little lighter than boys but gain at nearly the same rate. The rapid gain of infancy diminishes steadily to the fourth year; the gain continues at a nearly uniform rate for both sexes for the next five years. It then steadily rises, reaching the maximum in girls during the thirteenth year, and in boys during the sixteenth year. There is, however, frequently seen in both sexes a slight slowing up in the rate of gain just before the rapid increase when puberty begins.

**Seasonal Growth.**—After infancy there are few children who maintain throughout the year a uniform rate of gain, although they may make for the year the average increase. There are seen with nearly all healthy children periods often of several months' duration in which the weight is nearly stationary followed by periods of rapid increase. This often occurs without evident cause. We have published 700 observations made in a New York private school upon boys from nine to sixteen years old, which showed that the gain in weight was on the average  $1\frac{1}{4}$  pound more for the six months from May to November (the months when records were made) than in the six months from November to May. During the first-mentioned period the increase in height also was 0.36 inch greater. W. T. Porter has published the results of monthly observations upon the growth of about three thousand school children in Boston for a period of years, *i.e.*, from the beginning of the sixth to the middle of the fifteenth year. His figures show



that the period of most rapid increase in weight is the summer and fall months; that of the slowest increase is in the winter and spring months. During the five months from January to June the average gain per month was but  $2\frac{1}{2}$  ounces; during the seven months from June to January it was  $12\frac{1}{3}$  ounces. One important factor in this difference would seem to be the greater amount of illness among children of school age which occurs during the first half of the year. The figures for New York City for a five-year period show that the average monthly death rate for these ages was 260 from January to July, and 211 from July to January. The seasonal variation in growth in height is much less marked. In the series of cases studied by Porter the average increase in height during eight years of observations was 8 inches from December to June, and  $8\frac{1}{4}$  inches from June to December.

**Relation of Weight to Nutrition.**—The relationship between weight and nutrition is a very close one. Formerly weight was considered with reference to

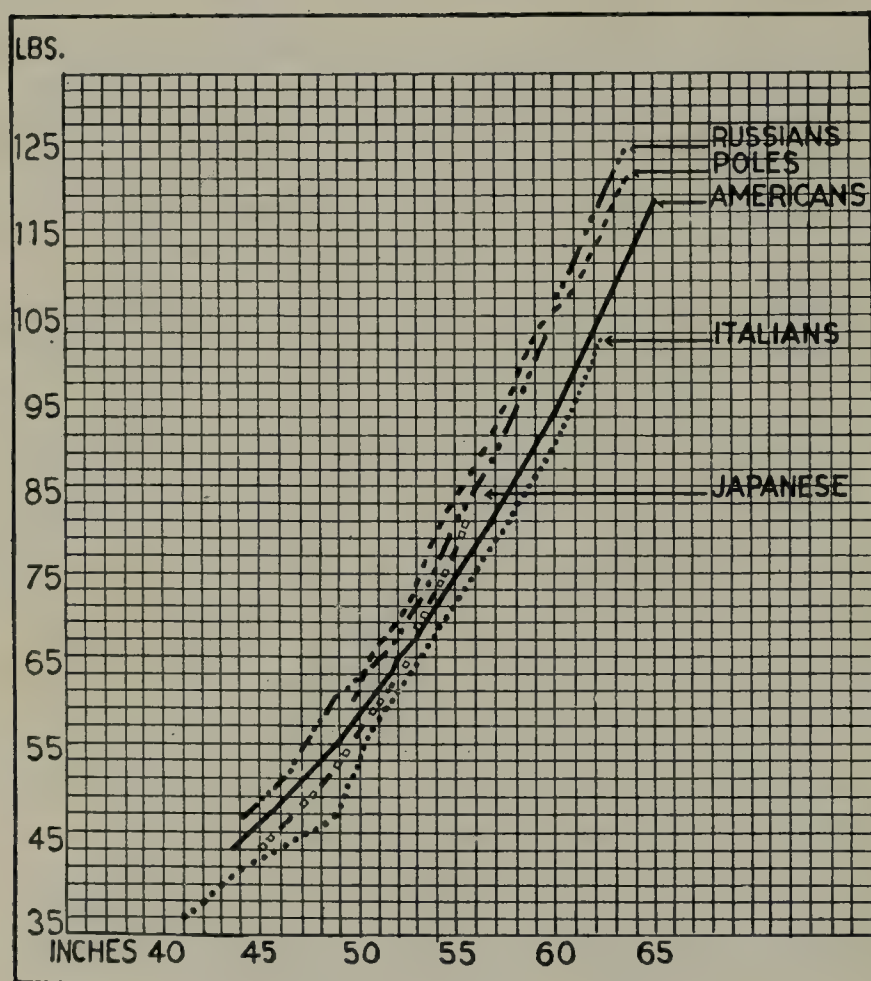


FIG. 2.—AVERAGE WEIGHT FOR HEIGHT OF BOYS.

2,500 Russian, 1,250 Polish (tall races); 9,000 Italian, 900 Japanese (short races); 13,000 American boys. (Foreign weights and heights quoted from Baldwin; American from Bowditch.)

above, was 50 pounds at twelve years, and 60 pounds at fourteen years, in both cases excluding the extremely high and extremely low weights.

The relationship of weight to height shows no such wide variations and is surprisingly little affected by race conditions (Fig. 2). However, age is not to be entirely ignored; for of two children of the same height, but of different ages, the older one should weigh more.

The average or standard weight for a given height and age is given in Tables IV

the child's age. Now weight for height is regarded as more significant. During infancy, however, accurate measurements of height are somewhat difficult, and those made by the average mother or nurse cannot be depended upon. For these reasons we have considered weight for age only during the first two years as the best practical index of the child's nutrition, although it is not so accurate as the weight for height. After the age of two years, when the standing height can be readily taken, the weight should always be related to height. Weight for age shows such wide variations due to race, family inheritance, individual peculiarities, etc., that it cannot be used as an index of nutrition. Thus the range of variation in the weight of healthy boys of the same social condition in the school mentioned



and V.<sup>2</sup> There are considerable variations seen in children who are perfectly healthy, which must be regarded as normal. How wide a variation from the average shall be considered normal is a somewhat arbitrary matter. For practical purposes, up to the age of twelve years, children whose weight is 10 per cent or more below the average for the height may be regarded as undernourished. Those who are more than 15 per cent above the average for height may be regarded as overweight. This would include as normal a child of 35 inches, who is 3 pounds below average weight; one of 41 inches, who is 4 pounds below; one of 46 inches, who is 5 pounds, and one of 50 inches, who is 6 pounds below. After the age of twelve, as children gain rapidly and less regularly, a somewhat wider range must be allowed; *i.e.*, those who are not more than 12 per cent below, and those who are not more than 20 per cent above the average may be considered normal.

During the second and third years, monthly weights should be taken, and after this time monthly or bimonthly weights during the entire period of growth of all healthy children. More frequent observations should be made in the case of delicate children or those who are much below the normal average.

Even more important than the actual weight of a child of any height or of any age is his progress or rate of gain. The weight must be taken over a considerable period to be significant; since as we have already seen the rate of gain differs at different seasons. The average annual rate of gain for the different ages is given in the table on page 24, and in Figure 3. A child whose gain falls much below this should be closely observed. A stationary weight for a prolonged period, or a continuous loss at any time, is a warning which should always be heeded.

HEIGHT

Measurements of 442 infants born at term taken in about equal numbers from the records of the New York Infant Asylum and the Sloane Hospital gave the following results:

<i>Infants Born at Term</i>		<i>Average Length</i>
231 males .....	20.6	inches (52.3 cm.)
211 females .....	20.5	inches (52.1 cm.)
<hr/> 442 infants .....		20.55 inches (52.2 cm.)

During the first year the average normal growth is 9 inches (22 centimeters). From about two thousand personal observations upon children from one to five years old, chiefly from private practice, it appears that during the second year the average growth is 4 inches; for the third year it is about 3½ inches; for the fourth year it is 3 inches. According to Bowditch's figures, after five years it is about 2 inches a year up to eleven years in girls and thirteen in boys, when the

<sup>2</sup> In these tables, the figures given are for children without clothes. The weight of indoor clothing varies less in individuals, sex and season than is commonly supposed. From personal observations made in private practice chiefly, the average weight of clothing for younger children of both sexes is as follows:

<i>Pounds</i>		<i>Pounds</i>	
At 1 year .....	1 to 1¼	3 years .....	1¾ to 2
2 years .....	1½ " 1¾	4-6 years .....	2 " 3

The difference between summer and winter clothing, even in the older groups, is seldom over half a pound and often less than this.



TABLE IV

NORMAL WEIGHT IN POUNDS FOR

Height, Inches	BOYS														
	2 Yrs.	2½ Yrs.	3 Yrs.	3½ Yrs.	4 Yrs.	4½ Yrs.	5 Yrs.	6 Yrs.	7 Yrs.	8 Yrs.	9 Yrs.	10 Yrs.	11 Yrs.	12 Yrs.	13 Yrs.
32	25	25													
33	26	26													
34	27	27	28												
35	28	29	29	29											
36	29	30	30	30	31										
37	31	31	31	32	32	33									
38		32	32	33	33	34	34								
39			34	34	34	35	35	35							
40			35	35	35	36	36	36							
41				37	37	37	38	38	38						
42					38	39	39	39	39	39					
43						41	41	41	41	41					
44						43	44	44	44	44					
45							46	46	46	46	46				
46							47	48	48	48	48				
47							49	50	50	50	50	50			
48								52	53	53	53	53			
49								55	55	55	55	55	55		
50								57	58	58	58	58	58	58	
51									61	61	61	61	61	61	
52									63	64	64	64	64	64	64
53									66	67	67	67	67	68	68
54										70	70	70	70	71	71
55										72	72	73	73	74	74
56										75	76	77	77	77	78
57											79	80	81	81	82
58											83	84	84	85	85
59												87	88	89	89
60												91	92	92	93
61													95	96	97
62													100	101	102
63													105	106	107
64														109	111
65														114	117
66															119
67															124

more rapid growth of puberty begins (Fig. 3). Both sexes grow at approximately the same rate up to this time; the girls pass the boys during the twelfth and thirteenth years, but are passed by them in the fourteenth and fifteenth years. Height is much more affected by inheritance than is weight. As a rule, in health, increase in weight and growth in height go on together. But in the young the



TABLE IV

A CHILD OF GIVEN HEIGHT AND AGE

GIRLS															Height, Inches
2 Yrs.	2½ Yrs.	3 Yrs.	3½ Yrs.	4 Yrs.	4½ Yrs.	5 Yrs.	6 Yrs.	7 Yrs.	8 Yrs.	9 Yrs.	10 Yrs.	11 Yrs.	12 Yrs.	13 Yrs.	
22	23														31
24	24														32
25	25	25													33
26	26	27													34
27	28	28	28												35
29	29	29	29	30											36
30	30	31	31	31	31										37
	31	32	32	32	33	33									38
		33	33	33	34	34	34								39
			34	35	35	36	36	36							40
			36	36	37	37	37	37							41
				37	38	39	39	39							42
				39	40	41	41	41	41						43
					42	42	42	42	42						44
					44	45	45	45	45	45					45
						47	47	47	48	48					46
						49	50	50	50	50	50				47
							52	52	52	52	53	53			48
							54	54	55	55	56	56			49
							56	56	57	58	59	61	62		50
								59	60	61	61	63	65		51
								63	64	64	64	65	67		52
								66	67	67	68	68	69	71	53
									69	70	70	71	71	73	54
									72	74	74	74	75	77	55
										76	78	78	79	81	56
										80	82	82	82	84	57
											84	86	86	88	58
											87	90	90	92	59
											91	95	95	97	60
												99	100	101	61
												104	105	106	62
													110	110	63
													114	115	64
													118	120	65
														124	66
														128	67

impulse to grow is very great; growth in height may take place when there is no gain and sometimes when there is actual loss in weight.

Malnutrition retards growth in height, but to a much less degree than it does weight. Rickets greatly affects growth in height; at three years children with marked rickets are often 5 or 6 inches below average height. Much of this differ-

ence is usually made up by later growth, but many children remain permanently shorter because of early rickets.

TABLE V  
AVERAGE ANNUAL INCREASE IN WEIGHT AND HEIGHT \*

Age, Years	Boys		Girls	
	Pounds	Inches	Pounds	Inches
0- 1 .....	14.0	9.0	13.5	8.5
1- 2 .....	6.0	4.0	6.0	4.0
2- 3 .....	5.0	3.5	5.0	3.5
3- 4 .....	4.0	3.0	4.0	3.0
4- 5 .....	4.0	2.5	4.0	2.5
5- 6 .....	4.0	2.0	4.0	2.0
6- 7 .....	4.0	2.0	4.0	2.0
7- 8 .....	4.75	2.0	4.5	2.0
8- 9 .....	5.25	2.0	5.0	1.75
9-10 .....	6.0	2.0	5.25	2.25
10-11 .....	5.0	1.7	6.5	2.0
11-12 .....	6.5	1.8	9.5	2.5
12-13 .....	8.0	2.0	10.5	2.0
13-14 .....	10.0	2.5	9.5	2.0
14-15 .....	12.5	2.7	7.5	1.25
15-16 .....	13.75	2.7	6.0	0.75
16-17 .....	6.5	1.2	3.5	0.50
17-18 .....	5.0	0.5	0.5	0.20

\* The figures from birth to five years are chiefly from personal observations; those above five years are averages calculated from about 100,000 observations upon children in public and private schools in the United States, compiled from ten different authors.

GROWTH OF THE EXTREMITIES AS COMPARED WITH THE TRUNK

At birth the trunk is relatively long and the extremities short. The middle of the body at birth, according to one hundred observations on normal infants made at the Sloane Hospital, is ¾ inch (2 centimeters) above the center of the umbilicus. The extremities normally grow much more rapidly than the trunk. At birth the measurement from the anterior superior spine of the ilium to the sole is 43 per cent of the body length; at five years, 54 per cent; at sixteen years, 60 per cent. These facts are of some assistance in the diagnosis of conditions affecting normal growth, such as rickets, cretinism and chondrodystrophy.

THE HEAD

**Circumference.**—The average circumference of the head at birth in 446 full term infants observed at the Sloane Hospital and New York Infant Asylum was as follows:

<i>Average Circumference of the Head (Occipitofrontal)</i>	
231 males .....	13.9 inches (35.3 cm.)
215 females .....	13.5 inches (34.3 cm.)
446 infants .....	13.7 inches (34.8 cm.)



The growth of the head is most rapid during the first year, the increase being about four inches (10 centimeters). It is about half an inch a month during the early months, and a fourth of an inch a month during the later months of the first year. During the second year the increase is about one inch (2.5 centimeters). From two to five years the growth is about one and a half inch (4 centimeters) for the three years. After the fifth year, up to puberty, the increase is slow, being at the rate of about one-half inch in five years.

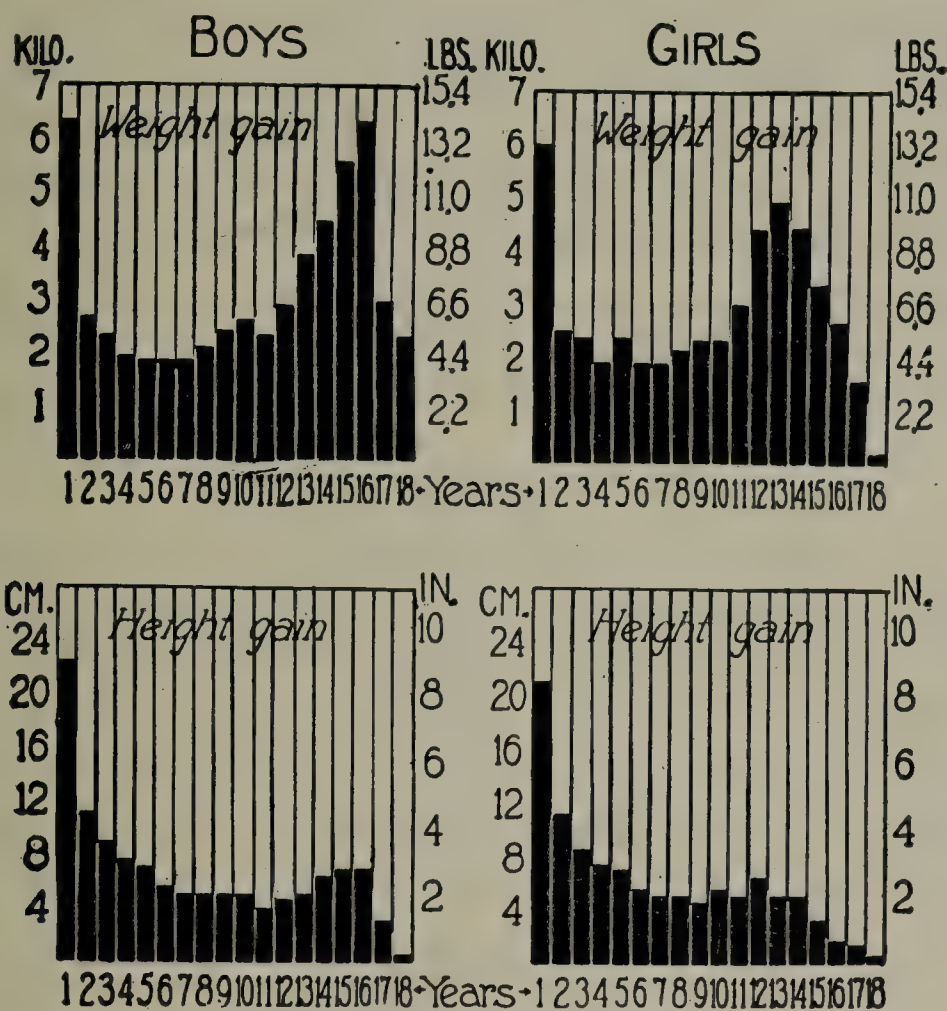


FIG. 3.—ANNUAL INCREASE IN HEIGHT AND WEIGHT.

**Closure of the Sutures.**—Distinct separation of the cranial bones after birth is abnormal. It is most frequently seen in premature infants. The main sutures of the cranium are not commonly ossified before the end of the sixth month, and very frequently some mobility may be detected at the end of the ninth month.

**Closure of the Fontanel.**—The posterior fontanel is usually obliterated between the sixth to eighth week. The anterior fontanel normally closes between the fifteenth and eighteenth months. The usual variations are between the fourteenth and twenty-second months. At the end of the first year the fontanel is generally about three-fourths of an inch in diameter. An open fontanel at the end of the second year may be considered abnormal. The closure of the fontanel is not always early in well-nourished children, nor is it always delayed in those suffering from malnutrition. In very rare cases the anterior fontanel may either be closed at birth or may close during the first few weeks of life. Closure of the fontanel by the middle of the first year is often seen in cases of arrested cerebral development such as is found in microcephalus.

By far the most frequent cause of delayed closure of the fontanel is rickets, in which condition it may be open up to the end of the third year. A large fontanel

is one of the striking features of cretinism, and in untreated cases is often seen as late as the eighth year or later. In infancy a widely open fontanel with a rapid growth of the head should at once suggest hydrocephalus. There is an hereditary condition (*dysostosis cleidocranialis*) in which the fontanel remains open even to adult life. It is often associated with lack of union between the two portions of the clavicle.

**Shape of the Head.**—The deformity which results from compression during labor usually disappears by the end of the first month. During the first year the head often becomes flattened at the occiput in consequence of the child's lying too much upon the back. This is easily remedied by changing his position. A slight obliquity of the head may result from an habitual position during nursing or sleeping. A marked degree of obliquity is quite often congenital, but usually disappears by the third or fourth year.

The other abnormalities in the shape of the head are chiefly due to rickets and hydrocephalus, to congenital malformations of the brain, and to anomalies of closure of the cranial sutures. They will be considered in the chapters devoted to these topics.

TABLE VI

AVERAGE NET WEIGHT, HEIGHT AND CIRCUMFERENCE OF HEAD AND CHEST OF HEALTHY CHILDREN FROM BIRTH TO THREE YEARS

Age	Sex	Weight		Height		Chest		Head	
		Pounds	Kilos.	Inches	Cm.	Inches	Cm.	Inches	Cm.
Birth .....	Boys	7.55	3.43	20.6	52.5	13.4	34.2	13.9	35.2
	Girls	7.16	3.26	20.5	52.0	13.0	33.0	13.5	34.3
6 months .....	Boys	16.0	7.26	26.5	67.4	16.5	41.9	17.0	43.2
	Girls	15.5	7.03	26.0	66.1	16.1	40.8	16.6	42.3
12 months .....	Boys	21.0	9.54	29.5	75.0	18.0	45.7	18.0	45.7
	Girls	20.5	9.31	29.0	73.7	17.5	44.5	17.5	44.5
18 months .....	Boys	24.5	11.13	31.5	80.0	18.7	47.8	18.6	47.5
	Girls	23.7	10.77	31.0	78.8	18.2	46.2	18.0	45.7
2 years .....	Boys	27.0	12.27	33.5	85.1	19.3	49.1	19.2	48.7
	Girls	26.0	11.81	33.0	83.8	18.8	48.0	18.6	47.5
2½ years .....	Boys	29.7	13.50	35.5	90.2	19.8	50.4	19.5	49.5
	Girls	28.7	13.04	35.0	89.0	19.3	49.1	19.0	48.2
3 years .....	Boys	32.0	14.54	37.0	94.0	20.3	51.5	19.8	50.4
	Girls	31.0	14.09	36.5	92.8	19.8	50.4	19.4	49.3

THE CHEST

Measurement of the chest should be taken midway between full inspiration and expiration and at the level of the nipples. The figures for children up to the age of three years given in Table VI are from personal observations. Thereafter, according to the observations of Porter and Bowditch upon over 37,000 children, the average growth of the chest is about one inch a year up to fifteen years, when the average measurement is 30 inches in both sexes.

In the newly born child the anteroposterior and the transverse diameters of the



chest are nearly the same. As age advances, the transverse diameter increases very much more rapidly, so that the outline of the chest gradually assumes an elliptical shape, which it maintains during childhood.

At birth, the circumference of the chest is about one-half inch less than that of the head, but at one year of age the two measurements are nearly the same. It is not until the second year that the average circumference of the chest exceeds that of the head. The chest measurement in infants is always much modified by the amount of fat; but, after making due allowance for this, a large chest always indicates a robust child and a small chest a delicate one. If at any age the circumference of the child's chest is found to be much below the average, means should be taken, by gymnastics and otherwise, to develop it.

In infants deformities of the thorax result chiefly from rickets, sometimes from empyema, emphysema, and cardiac disease; in older children, from lateral curvature of the spine, or from Pott's disease. A peculiar deformity, usually congenital, and sometimes hereditary, is the funnel-shaped chest, the *Trichterbrust* of the Germans. It consists in a deep pit-like central depression at the lower end of the sternum. It is usually permanent.

### THE ABDOMEN

Throughout infancy the circumference of the abdomen is, as a rule, about the same as that of the chest. At the end of the first year the measurements of the head, chest, and abdomen are very often identical; after this time the chest measurement increases much more rapidly than the other two. Marked enlargement of the abdomen is seen in many varieties of chronic intestinal disorders. The tympanites that often accompanies rickets is a frequent cause of enlargement.

### MUSCULAR AND MENTAL DEVELOPMENT

The first voluntary movements are usually in the fourth month, when the infant deliberately attempts to grasp some object placed before him. During the fourth month, as a rule, the head can be held erect when the trunk is supported. In many infants this is possible in the early part of the third month. At seven or eight months a healthy child is usually able to sit erect and support the trunk for several minutes.

In the ninth or tenth month are usually seen the first attempts to bear the weight upon the feet. At eleven or twelve months a child usually stands with slight assistance. The first attempts at walking are commonly seen in the twelfth or thirteenth month. The average age at which children walk freely alone has been, in our experience, the fourteenth or fifteenth month. Quite wide variations are seen in healthy children. Very much depends upon the surroundings. We have known infants to walk at ten months and many others not until seventeen or eighteen months, although showing no evidences of disease, and although their development had not been retarded by previous illness. A very marked difference is seen in different families with respect to the time of walking.

The physician is often consulted because of backward muscular development, most frequently because the child is late in walking. General malnutrition, or any severe or prolonged illness, may postpone for several months this or any of the



other functions mentioned. When there is no such explanation of the backwardness, a child who does not hold up his head, sit alone, or make efforts to stand or walk at the proper time, should be submitted to a careful examination for mental deficiency or cerebral or spinal paralysis, but especially for rickets, which is the most frequent explanation of the symptoms.

Contrivances for teaching infants to walk are unnecessary, and their effect may even be injurious. An infant should be allowed the greatest possible freedom in the use of his limbs. He should not be restrained from walking, when inclined to do so, or continually urged to walk when no voluntary attempts are made. Nothing short of mechanical restraint will prevent a healthy child from walking or standing when he is strong enough to do so.

### DEVELOPMENT OF THE SPECIAL SENSES

**Sight.**—The newly born infant avoids the light. The pupils contract in a light room, and if a bright light is brought before the eyes they close. During the first few weeks the infant indicates by every sign that excessive light is unpleasant. As early as the sixth day the eyes will sometimes follow a light in the room, and the child may even turn the head for this purpose. The muscles of the eyes of the newly born infant act irregularly and not in harmony. Coördinate action for general purposes is not established until about the end of the third month. Even after this time incoördinate action is occasionally seen. The eyelids also move irregularly, and are often partly separated during sleep. The cornea is but slightly sensitive during the first weeks. In Preyer's child it was not until the third month that the lids closed when the water in the bath touched the lashes or the cornea. The recognition of objects seen is usually evident in the sixth month.

It is important that the room in which the newly born child is placed should be darkened, and that for the first few days the eyes should be protected against strong light.

**Hearing.**—For the first twenty-four hours after birth infants are deaf. This deafness sometimes persists for several days. It is believed to be due to absence of air from the middle ear, which is at birth completely filled with embryonic mesenchyme. Within a few days the hearing gradually develops, and during the early months of life it is very acute. The child starts at the slamming of a door, and even moderately loud noises will waken him from sleep. By the end of the second month he will sometimes turn his head in the direction from which the sound comes, and by the end of the third month this will usually be done. Demme found, in observations upon 150 infants, that voices were recognized on an average at three and a half months.

Not only are the ears unusually sensitive to sound in infancy, but the impression produced upon the brain is often marked—very loud sounds resulting in great fright.

**Touch.**—Tactile sensibility is present at birth, but is not highly developed except in the lips and tongue, where it is very acute for the obvious necessity of sucking. After the third month it is fairly acute over the surface of the body generally. Two especially sensitive areas, according to Preyer, are the forehead and external auditory meatus.



Sensibility to painful impressions is present in early infancy, but is dull as compared with later childhood.

Differences of temperature are also readily distinguished. This recognition is especially acute in the tongue. A young infant often refuses to take the bottle because the milk is only a few degrees too cold or too warm.

The localization of sensory impressions comes later, probably not much before the middle of the sixth month, and is very imperfect throughout the first year.

**Taste.**—This is highly developed, even from birth. According to the experiments of Kussmaul, the ability to distinguish sweet, sour and bitter, exists in the newly born child—sweet exciting sucking movements, and bitter, grimaces. A young infant detects with surprising accuracy the slightest variation in the taste of his food, and the smallest difference is often enough to cause him to refuse the bottle altogether. Sweet substances are always easily administered, and in combination with syrups even very bitter substances can be given; but to aromatic powders and elixirs he usually objects.

**Smell.**—Observations upon the sense of smell in newly born infants are few and not altogether conclusive. Kroner's experiments appear to show that smell is present in the newly born. It has been noted to be especially acute in infants born blind. The sense of smell is developed much later than the other senses. Detection of fine differences in odors is not acquired until quite late in childhood.

## SPEECH

There is a very wide variation in children with reference to the time of development of the function of speech. Girls, as a rule, talk from two to four months earlier than boys. Towards the end of the first year the average child begins with the words "papa," "mamma." By the end of the second year he is able to put words together in short sentences of two or three words. Progress in speech from this time is very rapid, each month showing great improvement. Names of persons are commonly first acquired, then the names of objects. Next to this the verbs are learned, and then adverbs and adjectives. Conjunctions, prepositions, and articles follow in order, and last of all the personal pronouns.

If a child of two years makes no attempt to speak, it may usually be inferred that there is some mental defect or that the child is a deaf mute. Exceptionally there are seen children of normal mentality with perfect hearing who are able to make known their wants by signs so perfectly that they seem to feel no need of speech. In such cases speech may be postponed a year or two beyond the usual time and yet be perfect. The best treatment is association with other children.

## DENTITION

The teeth are enclosed at birth in dental sacs which are situated in the gums. Superficially they are covered by the submucous connective tissue and the mucous membrane; the dental sacs rest in depressions in the alveolar process of the jaw. The tooth grows in length mainly as the result of the growth of its roots, and, as the growing root becomes calcified, the tooth, being thus fixed below, pushes upward towards the mucous membrane. This growth undoubtedly goes on steadily from birth until the tooth pierces the gum.



**The Deciduous Teeth.**—The deciduous or milk teeth are twenty in number. The time at which they appear is subject to considerable variation even under normal conditions. The following is the order and the average time of appearance of the different teeth:

1. Two lower central incisors.....	6 to 9 months
2. Four upper incisors .....	8 to 12 months
3. Two lower lateral incisors and four anterior molars	12 to 15 months
4. Four canines .....	18 to 24 months
5. Four posterior molars .....	24 to 30 months

At 1 year a child should have.....	6 teeth
At 1½ years a child should have.....	12 teeth
At 2 years a child should have.....	16 teeth
At 2½ years a child should have.....	20 teeth

Quite wide variations on both sides of the average are common, and are not always easy of explanation. In many cases it seems to be a family idiosyncrasy, since in the different members of a family the teeth are apt to appear at about the same time.

The order in which the teeth appear is much more regular than the time of their appearance. Slight variations are exceedingly common, but marked irregularities in the order of the appearance of the teeth are the rule in children suffering from mental or other defects.

The teeth may pierce the gum without any local manifestations. Very frequently, however, just before a tooth comes through there is noticed a moderate swelling and redness of the mucous membrane of the gum overlying it, and to a slight degree this may affect the general mucous membrane of the mouth. This condition may be accompanied by a little fretfulness and increased salivation. These symptoms usually disappear when the tooth has pierced the gum. The symptoms of difficult dentition will be discussed in connection with diseases of the mouth.

Infants may be born with teeth. We know of one family in which this occurred in three members of three successive generations. It is, however, rare. It is almost invariably one of the lower central incisors that is present. In case this interferes with nursing, or if it is very loosely attached to the gum, it should be extracted, but under other circumstances it should be allowed to remain, since if it is removed, a second tooth is not likely to appear in its place in the first set. It is not at all uncommon for the first teeth to appear in the fourth month. Such teeth, in our experience, do not usually differ in character from those appearing later, unless they are in children who are syphilitic. Syphilitic children are rather prone to early dentition, and under such circumstances rapid and early decay is likely to take place.

Delayed dentition is usually due to rickets. However, in many healthy infants no teeth appear before the tenth month, and we have occasionally seen the first ones at thirteen months in those who seemed perfectly healthy and showed no other evidence of rickets. On the other hand, it is by no means invariable that dentition is late in rachitic children. This depends upon the time when the rickets develops.



The latest dentition is seen in cases of cretinism. In such children it is not rare for the first teeth to appear as late as eighteen months or two years. As a rule, dentition and ossification of the bones of the head go on in a corresponding manner; where one is early the other is likely to be rapid, and conversely. Great irregularities in dentition are common in children with defective cerebral development.

Provided an infant is well nourished and thrives properly for the first six or eight months, the eruption of the teeth is likely to go on steadily after this time, even though the child may later have chronic indigestion or suffer from extreme malnutrition from any cause except rickets. If, however, the symptoms of malnutrition date from birth, dentition is almost invariably delayed.

It is often a matter of very great surprise to see children who are markedly emaciated as a result of chronic nutritional disturbances go on cutting their teeth regularly. We once had under our care a delicate infant of sixteen months, whose body length was 28 inches and whose weight was less than nineteen pounds—almost exactly what they had been eight months previously—and yet he had thirteen teeth.

**Eruption of the Permanent Teeth.**—The first to appear are the first molars, which usually come in the sixth year, and hence the name six-year molars which is applied to them. These appear posterior to the second molars of the first set.

The incisors and canines replace the corresponding teeth of the first set. The eight bicuspid take the place of the eight molars of the first set. The molars of the permanent set appear back of the bicuspid, room being made for them by the growth of the jaw. As they grow and push upward the permanent teeth cause atrophy of the roots of the first teeth, and gradually cut off their blood supply, so that they loosen and fall out.

The following table gives the average time of the appearance of the second teeth:

	20 12 6 10 9 11 8 7
	<i>Age, Years</i>
First molars .....	6
Incisors .....	7- 8
Bicuspid .....	9-10
Canines .....	12-14
Second molars .....	12-15
Third molars .....	17-25

The place of dentition as an etiological factor in the diseases of infancy will be considered in the chapter on Diseases of the Teeth.

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## CHAPTER IV

### PECULIARITIES OF DISEASE IN CHILDREN

In many particulars disease in children differs from that of later life. The greatest contrast to adult life is presented by infancy and early childhood. After seven years, children in their diseases resemble adults more than they do infants.

#### ETIOLOGY

**Inheritance.**—There may be direct transmission of an infectious agent to the child *in utero*. The disease commonly transmitted in this manner is syphilis, but in rare instances tuberculosis, typhoid fever, malaria, pertussis, measles and other contagious diseases have been so conveyed. Poisons, like lead, may be transmitted through the placenta, and infants be born suffering from lead poisoning. Deficiency diseases, such as beriberi, may be acquired *in utero*; congenital rickets occurs in infants whose mothers are suffering from osteomalacia.

In other instances children may inherit constitutional weaknesses and tendencies which manifest themselves as disease either in infancy or during later life. Under this head we may place diabetes, the diseases of allergy, many of the degenerative diseases of the muscles and nervous system, functional neuroses and psychoses.

**Congenital Malformations.**—These are of interest, particularly during the period of infancy, since it is at this time that they are usually discovered. Some malformations, as for example polydactylism, are definitely hereditary. Others may be attributed to faulty fetal environment or, rarely, to intra-uterine disease. From a medical standpoint, the most important malformations are those of the heart, stomach and intestines, and kidney; those involving the mouth, nose, central nervous system, extremities, bladder, rectum, and genital organs belong more particularly to the domain of surgery.

**Diseases or Accidents Connected with Birth.**—Some of these are traumatic, like the intracranial hemorrhages, peripheral nerve paralyses, and fractures. The entire philosophy of life of an emperor has recently been alleged to have been influenced by an Erb's palsy. Under this heading must be placed also the peculiarities of premature infants, and the chemical changes responsible for physiological icterus and hemorrhagic disease of the newborn. Infections also play a large part, gaining entrance usually through the umbilical wound, more rarely through the skin or mucous membranes; these include pyemia, with its varied lesions throughout the body, erysipelas, ophthalmia, tetanus, and many of the pulmonary and intestinal diseases occurring at this age.

**Disturbances of Growth and Nutrition.**—This category, together with the succeeding one dealing with infections, includes the great majority of abnormal conditions with which the physician has to deal in the care of infants and children,



The hygiene of food, clothing, and rest is involved. Many of the feeding problems of the first years have to do with abnormal metabolism of food elements. In some diseases such as rickets and scurvy, there is an actual deficiency of certain essential food factors. Abnormalities of the internal secretions may lead to dwarfism as in cretinism, to gigantism as in certain pituitary disorders, to precocious sexual development as in some suprarenal tumors. Some of the etiological factors in this category are traumatic or mechanical, having to do with faulty posture, obstructions in the nasopharynx such as adenoids, improper habits such as thumb-sucking. Often the lasting effects of chronic infections of long standing, or of repeated acute infections recurring in the same organs, are focused on growth and development.

**Infections.**—These play a peculiarly large part in infancy and childhood; for in addition to the common pyogenic infections there occur the specific contagious diseases against which adults are commonly protected by previous attack. The peculiarities of infection and resistance in childhood will be discussed in connection with immunology. The seasonal incidence of infections is particularly striking; in general, those of the respiratory tract occur in the winter and spring; those of the alimentary tract in summer and early fall.

**Neoplasms.**—Certain types of tumor are more common in early life than later, notably hemangiomata and lymphangiomata. In some organs, particular tumors occur with special frequency: thus, from the point of view of probability, a tumor in the brain is likely to be a glioma or neuroblastoma; one of the kidney, a mixed tumor or embryoma, or a neuroblastoma. Malignant tumors are rarely carcinomata.

**Degenerative Changes.**—In some systems where these are peculiarly prominent in the adult, as in the arterial system, their occurrence in early life is so rare as to be practically negligible. On the other hand, the nervous system and to a less extent the muscular system may be the seat of changes of a degenerative type rarely seen in adults.

**Functional Disorders.**—Disease conditions based on abnormal physiology without demonstrable anatomic change are relatively frequent in early life. They pertain principally to the digestive and nervous systems.

## SYMPTOMATOLOGY AND DIAGNOSIS

In pediatrics, age plays a much more important part in differential diagnosis than in the diseases of adults. In older children the symptoms of disease are very much the same as in adults, and similar methods of examination may be employed. What is really peculiar to children belongs especially to the first three years of life, before speech has developed. During this period the chief and almost the sole reliance of the physician must be upon the objective signs of the disease. It is not so much that diseases in early life are peculiar, as that the patients themselves are peculiar.

Certain fundamental facts are always to be kept in mind. A sick infant or child is more likely to be suffering from only one disease, or the complications of one disease. The student approaching pediatric problems for the first time is often baffled by the variety and apparent remoteness of symptoms founded on a



single disease factor. Digestive and neurological symptoms so commonly accompany pathological processes, particularly inflammations, in practically any part of the body that they are not necessarily significant in pointing to those particular regions or systems as the site of trouble. Again, functional disorders of nearly any system of the body occur with great frequency and indeed at times with fatal severity.

**The History.**—In view of the fact that but little information can be had from the patient, it is important to obtain from the mother or nurse as full and complete information as possible. This is always most easily accomplished at the first visit, and should be done so thoroughly that no subsequent necessity occurs for going back into the history to pick up missing facts.

*Family History.*—This should begin with the parents, going farther back, if possible, in many cases of hereditary disease. One must know regarding tuberculosis, syphilis, allergic conditions, the general vigor of constitution and physical condition of both father and mother. Health during pregnancy, and previous miscarriages, if any, are important facts in the mother's history. One should know the number of other children living and their general health, the number dead and from what causes. A knowledge of the surroundings in which the child has lived may be necessary to appreciate the chances of exposure to tuberculosis, malaria, and many other forms of infection, as well as the origin of many functional disorders of the nervous system.

*Patient's Previous History.*—This should begin with birth. One should inquire whether the child was premature or born at term, regarding the character of the labor, whether natural or instrumental, tedious or precipitate, the condition and vigor of the child at birth, difficulty of resuscitation, early cyanosis, eruptions, hemorrhages, and convulsions. Next the methods of feeding should be taken up—how long entirely and how long partly breast-fed, the date of weaning and the form of artificial feeding then employed. If the patient is an infant, and the problem presented is one of its nutrition, all the reliable data relating to the feeding should be obtained, even to the minutest detail: the symptoms associated with the feeding of the various formulae used, and the reasons for change. The best idea of the child's growth and development may be obtained from a weight record if one has been kept. If not available, one must depend upon general statements as to how the child thrived at different periods. The date of the appearance of the first teeth and the time and the order in which the teeth came, are significant. The general muscular development may be best determined by learning when the child could first hold the head erect, sit alone upon the floor, bear the weight upon the feet, creep or walk alone; the mental development, by learning as to early recognition of mother or nurse, the bottle, understanding the meaning of words, speaking in words or sentences. The muscular and mental development of a normal child during the first two years is a subject with which the physician should be familiar if he would detect early those differences, often slight at this age, in children whose development is backward owing to cerebral lesions.

All previous attacks of acute illness of whatever character should be noted, particularly the infectious diseases—measles, scarlet fever, diphtheria, pertussis, mumps, influenza—with dates and details as to duration, severity, and complica-



tions. One should learn whether the child is especially prone to disorders of digestion or those of the respiratory system. Under the former head are included early difficulties in feeding, acute attacks of indigestion, diarrhea, or dysentery, also chronic disturbances of the stomach or bowels; under the latter head, frequent catarrhal colds, earache or otitis, catarrhal croup, bronchitis, pneumonia, or pleurisy. Other points to be investigated relate to attacks of tonsillitis, operations for the removal of hypertrophied tonsils or adenoids, and previous disorders of the nervous system. In infants, particularly important are extreme restlessness, somnolence, or convulsions; in those who are older, hysterical manifestations, epilepsy, or chorea. One should bear in mind that under the age of five years a convulsion may be the counterpart of a chill in an older patient, in regard to its association with an acute febrile disease; a history of convulsions is incomplete without a record of their relation to fever. One should know the date of successful vaccination, of immunization against diphtheria, and the result of the Schick test, the tuberculin test, or other such diagnostic procedures that may have been applied. Inquiry should also be made concerning any recent exposure to infection. Finally, an account in schedule form of the daily life of the patient at the time of the visit, or before the onset of the present illness, will furnish valuable information regarding habits, training, and the psychological aspects of the environment.

*Present Illness.*—One should first note the chief complaints as stated by mother or nurse. It is important to obtain as definite statements as possible as to the time when the child was quite well, and whether the onset of the illness was abrupt or gradual, and with what particular symptoms. In all digestive disorders one should know exactly concerning the child's food at the time of the onset, its quantity, character, and preparation; also any recent change in diet, the presence or absence of vomiting, and the condition of the bowels, whether loose or constipated, the frequency and character of the stools. General questions as to whether the bowels are regular or the stools normal are of no value, since the informant often is not capable of judging correctly.

Nervous symptoms, like the others, should be elicited in response to direct questions regarding sleep, restlessness, moaning, crying out, or other evidences of pain, excitement, delirium, or convulsions, or unnatural drowsiness. In any acute illness other important symptoms are fever, sweating, dyspnea, cough, hoarseness, nasal discharge, and the amount and character of the urine.

**The Examination.**—The ability to gain the patient's confidence in the first few moments helps in obtaining coöperation for the subsequent examination. While playing with an infant or conversing with an older child the physician may gain information of importance.

*General Inspection.*—In acute disease, the following points should be noted especially:

**NUTRITION AND GENERAL DEVELOPMENT.**—Whether the child is well nourished or the features pinched and wasted.

**FACIAL EXPRESSION.**—Whether it is bright and intelligent or dull and stupid, peaceful or anxious, quiet or disturbed, and whether the features are contracted from time to time, as if from pain.



**CHARACTER OF THE RESPIRATION.**—Whether it is rapid or slow, difficult or irregular; whether it is costal or abdominal in type and if there is any evidence of paralysis of the respiratory muscles; whether there is nasal obstruction, as indicated by snoring and mouth-breathing. Marked dyspnea is usually accompanied by active dilatation of the alae nasi.

**POSTURE.**—Whether the child lies upon the back, side, or face; whether the head is drawn back with general flexion of the extremities.

**NERVOUS CONDITION.**—Whether the child is restless, excitable, or drowsy and apathetic.

**COLOR OF THE SKIN OF THE FACE.**—Whether pale or cyanotic or jaundiced; and the lips, whether fissured or excoriated.

**AMOUNT OF PROSTRATION.**—A practiced eye can usually tell with older children whether the condition is grave or not, but infants not infrequently deceive even the most experienced observer.

**THE CRY.**—It is important, but not always easy, to determine whether a child cries from fright or bad training, from general irritability which may come from any acute disease, or from actual pain. The cry of fright is usually evident, because it comes with the physician's approach and ceases when he goes away. Children of indulgent parents will often cry when anything out of the usual routine occurs. The cry of pain may be distinctive; it may be accompanied by some attempt at localization, as when a child puts his hand to an inflamed part, but in infancy the pain of acute inflammation is often indicated only by general restlessness and irritability. The cry of some diseases is quite characteristic, as the short, catchy cry of acute pneumonia; the hoarse cry of laryngitis; and the sharp cry of a child with scurvy or some acute inflammatory process whenever his bed or body is touched.

**Measurements.**—These, though of greatest value in chronic diseases, particularly disturbances of nutrition, may be of assistance also in acute conditions. The important measurements are the circumference of the head and chest, and the body length. The circumference of the abdomen is at times important, but varies so much with the degree of distention that it is not significant as to the general development.

In taking the circumference of the head the largest measurement (over the occipital and frontal eminences) is preferable. The measurement of the chest is usually taken over the nipples. The body length of infants is best taken with a tape as the child lies upon his back upon a table or a firm bed. For older children a special measuring rod is convenient.

To estimate properly the significance of measurements they should be compared with the normal averages and with each other. It should be remembered that the head is normally larger than the chest until near the end of the first year; after this time, with a normal development, the chest should be larger. Any great disproportion between the size of the head and chest is suggestive of disease. The measurements form important means of recognizing early such abnormalities as microcephalus, cretinism and chondrodystrophy, the variations often being marked before the other symptoms are prominent. One who forms the habit of taking regular measurements soon appreciates the variations from the



normal, and gains great assistance from these data. Such a record made from year to year in children whose development is in any way abnormal is of great value in indicating what should be done in the way of exercise to correct faulty conditions.

*Pulse, Respiration, and Temperature.*—The significance of these signs is not to be measured by adult standards, since the susceptible nervous system of infants and very young children greatly exaggerates their reaction to all forms of acute infection.

The rate, regularity and quality of the pulse should be noted. In young children, the rate of the pulse is of less importance than its force and quality. A slow, irregular pulse is always significant; a slight irregularity of the pulse during sleep has no special significance. The pulse rate is much increased from slight disturbances; the approach of a stranger or the examination by the physician may cause it to rise 20 or 30 beats. In acute disease, a pulse rate of 150 is common, and 170 or 180 is often seen where other symptoms are not particularly severe.

The rate, depth, and rhythm of respiration should be noted. The last often cannot be determined except by attentively watching the child for several minutes. In premature and very young infants a rather marked irregularity may be seen, often approaching the Biot type. It is not to be taken as indicating a cerebral lesion, but seems rather to be due to the fact that the respiratory center is not yet fully able to control the movements. Respiration of this type is normally seen only during the first weeks of life. Irregularity of rhythm at other times should suggest cerebral disease. The respiration rate is proportionately greater in infants than in adults. In acute diseases of the lungs it not infrequently rises to 70 or 80, and occasionally it may be over 100 a minute. The rate is generally in proportion to the extent of the pulmonary lesion.

The temperature of infants and very young children should be taken in the rectum. Immediately after birth the temperature of the child is about the same as that of the mother, or a little higher. It falls from 1° to 3° F. in the course of the first few hours. Shortly thereafter it again rises to 98.5° or 99° F. (36.9° or 37.2° C.).

From a large number of personal observations upon healthy infants, we have found that the rectal temperature under normal conditions varies between 98° and 99.5° F.; occasionally the range may be as wide as 97.5° to 100.5° F. (36.4° to 38.1° C.) in apparently perfect health. The heat-regulating center in the brain acts only imperfectly in the young infant, and slight causes are enough to disturb the temperature.

The temperature in infants is usually higher than it is in adults from corresponding causes. Moreover, very high temperatures may be met with in cases not serious. In such cases the temperature seldom remains at a high point for more than a few hours. It is a continuous or recurring high temperature rather than a single rise which is significant of disease in infancy.

It is common in chronic wasting diseases, in delicate infants and in those prematurely born, to find the temperature one or two degrees below the normal; 95° and 96° F. (35.0° and 35.6° C.) are of almost daily occurrence in hospitals, and



much lower ones are not rare. Periodic observations should be made with the thermometer in such conditions, just as in fever.

Puzzling and apparently alarming temperatures are seen in infants as a result of the application of artificial heat. In one of our patients, an infant two days old, a temperature of 107° F. was caused by the close proximity of two large hot-water bags placed in the baby's basket. The younger and feebler the child the more readily are such temperatures produced.

*Muscular and Mental Development.*—The general muscular development is determined by seeing how well the children can hold up the head, sit alone, stand, or walk; the mental development in young infants, by the intelligence of expression, the manner in which they respond to stimuli, the recognition of objects, fright at strangers, etc.; later in the first year, by the use of their hands, their understanding of speech, and their ability to pronounce words.

*Local Examination.*—SKIN.—The skin should first be inspected for eruptions, and it is important that the entire eruption be examined in order that the distribution as well as the character of the lesion may be seen. Marked wrinkling or loss of elasticity of the skin is one of the best indications of loss in weight. The rapidity with which a fold of skin and subcutaneous tissue pinched up in the thumb and finger resumes its normal contour when released is a convenient measure of dehydration. Edema may be localized or general, increasing or receding. Bedsores are more frequently seen over the occiput than over the sacrum. Any large veins should be noted.

External glands should now be examined, especially the cervical, axillary, inguinal, and epitrochlear. The cause of a marked enlargement of any of these groups should be sought in the regions which they drain.

HEAD.—One should note whether the cranial sutures are ossified, unnaturally open or separated; also whether the fontanel is closed, or, if open, whether it is depressed or bulging. It is important to determine if there are prominences of the bones of the parietal and frontal regions, if there is a tumor projecting from a suture or limited to the area over the parietal or occipital bones. Craniotabes should be tested for during the first year.

EYES.—The condition of the conjunctivae and lids should be noted, also the presence of ptosis, strabismus, or other paralysis, but particularly the condition of the pupils, whether contracted or dilated, and the nature of their response to light. One should look also for the presence of corneal ulcers or opacities or of interstitial keratitis. The sclerae should be examined for the discoloration of jaundice.

EARS.—In infants and young children, examination of the ears and throat may well be postponed to the end of the physical examination on account of the fright these procedures are apt to cause.

NOSE.—The presence of any nasal discharge should be noted and its character determined. Cultures should invariably be made from purulent discharges. An abundant discharge tinged with blood, in young infants, should suggest syphilis; in older children, diphtheria; a chronic discharge, adenoid growths; a purulent discharge of one side, a foreign body.

MOUTH.—The appearance of the mucous membrane of the mouth and gums as well as the teeth may often be ascertained by watching the child while he is



crying. It should be noted whether the tongue is dry or moist, clean or coated; whether thrush is present or any other form of stomatitis, whether the gums are congested, swollen, or hemorrhagic. The number, position, and character of the teeth are important. The general color of the mucous membrane may be significant. Cyanosis or extreme pallor should be noted. On the mucous membrane of the hard palate may often be found the first local evidence of scarlet fever in the form of a minute punctate eruption, and on that portion of the cheeks opposite the molar teeth should be sought Koplik's sign, the earliest reliable symptom of measles.

THROAT.—A careful examination of the pharynx and tonsils should never be omitted in any acute illness, no matter what other symptoms may be present. Not only tonsillitis, but often diphtheria, is overlooked from a failure to observe this as an invariable rule. The inspection of the mouth and throat may wisely be put off toward the end of the examination, since it usually disturbs a child so as to embarrass further investigation.

NECK.—One should consider the position in which the head is held and the amount of rigidity of the cervical muscles. Considerable information may be derived in diseases of the nervous system by noting the ease with which the head is raised by the patient when the trunk is lifted from the supine to a sitting position.

CHEST.—In young children particular importance should be attached to the shape of the chest. Should deformities be present it should be determined if they are symmetrical. Rickets, pulmonary or cardiac disease may produce striking alterations in the configuration of the thorax. One should notice also the recession of the soft parts—intercostal spaces, the suprasternal notch, or the epigastrium; the amount of this is usually the best means of judging the severity of obstructive dyspnea. Details regarding the physical examination of the lungs are discussed in the introductory chapter to Pulmonary Diseases.

HEART.—It should be remembered that under two years loud cardiac murmurs are almost invariably of congenital origin, that soft murmurs at the base are very frequently functional, and that acquired cardiac disease is rare until after three years. Marked sinus arrhythmia is a common finding in children, and may lead an inexperienced observer to suspect an abnormality of conduction. For further details in the examination the reader is referred to the section on Diseases of the Heart.

ABDOMEN.—There should be noted the presence or absence of tympanites or abdominal tenderness, whether general or localized, the existence of retraction of the abdominal walls, the tone of the abdominal muscles and the condition of the overlying skin which best shows by wrinkling and loss of elasticity any degree of dehydration. The size and position of the liver and spleen are best determined by palpation. The lower border of the liver is usually slightly below the free border of the ribs. If the spleen can be easily felt below the ribs, it is, as a rule, enlarged. If it cannot be felt in a satisfactory examination, it is not sufficiently enlarged to be of any diagnostic importance.

SPINE.—Spinal curvatures should be examined for and, if found, it should be determined whether they are angular or gradual, permanent or reducible by change of posture.



**EXTREMITIES.**—The color of the extremities and the character of the peripheral circulation should be noted as well as any evidences of edema or hemorrhage in the form of punctate or larger extravasations. Clubbing of the fingers and toes should be looked for as well as any abnormality in the nails or desquamation of palms or soles frequently seen in congenital syphilis. In examining the extremities one should note especially the presence of tenderness, flaccidity, or rigidity of muscles, whether the limbs are wasted or plump, and the degree of muscular power; also any abnormal swelling on the shaft or near the extremities of the bones, and, finally, the function of the joints.

The reflexes may be very difficult to obtain in an infant at one examination and at another they may appear exaggerated. Lively patellar reflexes unless accompanied by rigidity and ankle clonus are not often indicative of disease. The plantar reflex of Babinski has little significance in infants, and in older children it is present in many conditions. Kernig's sign is a form of muscular spasm almost invariably present in meningitis, but often seen in other diseases.

Since satisfactory elicitation of the Chvostek sign is dependent on a certain degree of repose of the features, it is wise to make this test at the beginning of the examination of a patient before he has become disturbed.

**GENITAL ORGANS.**—Male children should be examined to determine the presence of phimosis or of undescended testicles. Hydrocele is a frequent condition, and may be mistaken for hernia. Both inguinal and umbilical herniae are very common. In female children it should be remembered that preputial adhesions may be considered normal, and are seldom the cause of the nervous symptoms attributed to them. Every vaginal discharge is significant, and if purulent should be examined bacteriologically. The great frequency of gonococcus infections is not appreciated, and they may be found when least expected.

The ears should invariably be examined otoscopically in all forms of febrile disturbance and from time to time in pneumonia, scarlet fever, measles, diphtheria, and other diseases involving the mouth and rhinopharynx. In any acute febrile condition, and particularly when otorrhea already exists, one should look for tenderness or swelling over the mastoid bone.

The examination is not complete without investigation of the urine and blood, and in infants of the stools as well. These will be dealt with in special chapters, and where other laboratory investigations are pertinent they will be considered in relation with the diseases with which they are concerned.

*Collection of Body Fluids for Laboratory Analysis.*—**URINE.**—In the collection of samples of urine from male infants, the penis is inserted into the mouth of a test tube of about 30 c.c. (1 ounce) capacity, held in place with adhesive tape or a T binder perforated to admit the tube. For female infants a test tube or bottle with mouth of 2.5 to 4 centimeters (1-1½ inch) diameter may be held against the vulva in the same way. The head of the bed should be raised a few inches. Another method is to place the infant, naked, on a sheet of waterproof material bolstered up around him in such a way that he lies in a depression. When pyuria is suspected, catheterization (size 9 to 11 French) is justified; it not infrequently happens that the infant will void when the tip of the catheter is applied to the urethral meatus.



BLOOD.—When a small amount of blood is required, as for hemoglobin estimation and cell counts, the infant's heel is often an easier region to work with than the finger-tip or ear. Preliminary immersion of the foot in hot water induces a capillary distention that favors a free flow, and it is sometimes possible to obtain several cubic centimeters in this manner, enough for Wassermann reaction or for certain chemical tests. If the capillary dilatation is adequate, blood so obtained has the characteristics of arterial blood. Amounts larger than about 0.5 c.c. are usually better taken by venipuncture.

CEREBROSPINAL FLUID.—This may be withdrawn from the lumbar subarachnoid space, the cisterna magna, or the cerebral ventricles. The lumbar route is used for all ordinary diagnostic purposes.

Spinal Puncture.—The patient is placed upon his side and held with the neck and thighs strongly flexed to separate the spines and laminae of the vertebrae. Under aseptic precautions the needle is inserted in the midline at the level of the crest of the ilium or just above this, and pointed straight forward or slightly cephalad. The distance it must be introduced in order to enter the subarachnoid space varies with the age, and to a lesser extent with the state of nutrition of the patient; as a rule, it is about 1.5 to 2.5 centimeters in infants, increasing to about 5 centimeters in children of three to five years of age. An experienced operator can tell from the sudden change of resistance to the needle when its point has pierced the dura, but without this skill the best procedure is to introduce the needle a small distance at a time and remove the obturator to see whether spinal fluid flows out. If by accident the tip traverses the subarachnoid space and meets the plexus of veins on the anterior wall of the spinal canal, contamination of the fluid with blood may occur. A slow flow may result from low pressure, from obstruction of the lumen with tissue or because the exudate is too thick to flow freely. Raising the patient to a sitting posture usually causes a freer flow, as does also flexing the head upon the chest or pinching the skin to make the child cry. Fluid should be collected in separate tubes, since in this way the needle is washed clear of traumatic blood by the first portion and the cell count in the last tube is made more reliable. A fairly satisfactory measure of spinal fluid pressure may be obtained by allowing the first fluid obtained to flow through a rubber connecting tube into a vertical glass tube of about 1 millimeter bore and using this as a water manometer. More accurate methods require special apparatus, but the error of uncontrolled intrathoracic pressure is so large that refined manometric methods ordinarily have no great advantage. When the purpose of the puncture is diagnostic, the withdrawal of from 6 to 10 c.c. of fluid is usually sufficient. For the reduction of pressure, or prior to the administration of serum, the fluid may be allowed to flow until it emerges at a rate of only one or two drops per minute. In this way one can safely withdraw from infants and children larger amounts in proportion to the body weight than would be possible with adults. When serum is injected, the amount should always be at least 5 c.c. less than the amount of spinal fluid previously withdrawn. After any spinal puncture the patient should be watched for ten or fifteen minutes for symptoms of collapse; this applies particularly when serum has been administered. However, reactions are less frequent and less severe with small patients than with adults. Only in



older children where there is danger of breaking the needle in a struggle should an anesthetic be used.

**Cistern Puncture.**—Puncture of the cisterna magna has advantages when meningeal exudate has produced a spinal block and when for other reasons it is impossible to obtain fluid from the lumbar region. Since by a slip in technic the needle may be introduced into the medulla, the operator should familiarize himself with the anatomical landmarks and, if possible, practice the procedure on a cadaver. The patient is placed on his side with the head strongly flexed. Under aseptic precautions the operator locates with a finger the uppermost cervical spine palpable, usually the third. Introducing the tip of the needle in the midline just above this level, he points it upward and forward in the direction of the anterior fontanel and advances it carefully. Usually this direction will bring the point of the needle against the occipital bone forming the posterior margin of the foramen magnum, in which case it should be withdrawn about half a centimeter and the point aimed in a little more horizontal direction before being again cautiously advanced. Perhaps this maneuver will be repeated two or three times before the dense membrane between the occiput and the atlas is encountered, but the advantage of making a preliminary false puncture in too vertical a direction is that if by chance the cistern should be entered at once and the needle advanced too far, its point would pierce the cerebellum rather than the medulla. Usually the density of the dural membrane at this point is so great that one has no difficulty in knowing when it has been pierced, and one should be careful to advance the needle no farther than the first point where fluid can be obtained. In careful hands the procedure is a safe one. We have used it and seen it used many times, and have never seen an accident.

**Ventricular Puncture.**—As long as the anterior fontanel is sufficiently patent to admit the introduction of a needle without danger of piercing the superior longitudinal sinus, it may be used for ventricular puncture, which is useful in the treatment of meningococcus meningitis and in the differentiation of causes of hydrocephalus. The head must be firmly held. Under aseptic precautions a long needle of the type used for lumbar puncture in adults is inserted at the lateral angle of the fontanel and directed downward and slightly outward. Since the depth at which the ventricle may be entered varies greatly with the age of the patient and the degree of dilatation, it is wise to advance the point of the needle about one centimeter at a time and withdraw the obturator to allow fluid to flow. Care is required to advance the needle without change of direction, to avoid destruction of brain tissue.

**PERITONEAL FLUID.**—Diagnostic puncture of the peritoneum is used not infrequently in infants, since the other signs of purulent peritonitis at this age are apt to be equivocal. Under the usual aseptic precautions, a needle of 18 or 20 gauge with a 45° bevel, to which a sterile syringe is attached, is introduced at a level halfway between the umbilicus and the symphysis pubis and either in the midline or at the lateral border of the left rectus muscle, pointed backward and diagonally upward. The bladder must not be distended at the time. From the thickness of the abdominal wall and the depth to which the needle has been introduced one can easily tell when the tip is in the peritoneal cavity. Gentle trac-



tion on the piston may cause a visible quantity of fluid to enter the syringe, but usually none is seen. Suction should be maintained, however, as the needle is withdrawn and the contents of the needle lumen used for examination and culture.

Aspiration of the pleural cavity in infants and young children is described under Diseases of the Lungs.

PROPHYLAXIS

There is no more promising field in medicine than the prevention of disease in childhood. The majority of the ailments from which children die it is within the power of man in great measure to prevent. Prophylaxis should aim at the solution of two distinct problems: (1) The removal of the causes which interfere with the proper growth and development of children; (2) the prevention of infection. The former can come only through the education of the profession and of the general public in the fundamental principles of infant feeding and child hygiene. The latter must come through the profession and through legislation, the purpose of which shall be to secure rigid quarantine and improved sanitation. The subject of prophylaxis will be discussed in connection with the different diseases.

PROGNOSIS AND INFANT MORTALITY

The younger the patient the worse the immediate prognosis in nearly all the diseases of childhood. This is in consequence of the feeble resistance of the infant and the digestive complications which are found in early life. On the other hand, if acute disease is survived the great changes in the tissues which result

TABLE VII  
CAUSES OF DEATH DURING FIRST FOURTEEN DAYS \*  
(10,000 confinements; \* premature births in heavy type)

Causes	Under 1 Day		Under 7 Days		7 to 14 Days		Total under 14 Days		Grand Totals
Congenital weakness .....	93	2	120	7	14	2	134	9	143
Accidents of labor.....	1	14	1	32	..	..	1	32	33
Pneumonia .....	..	..	3	9	3	13	6	22	28
Atelectasis .....	3	7	3	14	1	7	4	21	25
Congenital syphilis .....	5	..	6	1	6	..	12	1	13
Malformations .....	..	4	2	7	..	3	2	10	12
Hemorrhage .....	..	..	..	8	..	2	..	10	10
Sepsis .....	..	..	..	2	..	7	..	9	9
Asphyxia .....	..	7	..	8	..	..	..	8	8
Accidental .....	..	1	..	2	..	..	..	2	2
Undetermined .....	..	3	..	8	..	..	..	8	8
TOTAL .....	102	38	135	98	24	34	159	132	291

\* Abortions, 253; stillbirths, 429; living births, 9,318. Nearly half of the total mortality for the period covered was ascribed to congenital weakness, chiefly due to prematurity. Holt and Babbitt, *J. Am M. Ass.*, Jan. 25, 1915.

from growth, and the greater capacity for repair in early life make the ultimate prognosis often far better than would be the case with adults. The extent to which the consequences of disease may be "outgrown" is often remarkable, provided the nutrition of the body can be maintained at its best.



Table VII represents a study of neonatal mortality. It brings out the fact that within the first two weeks of life the innate vitality of the individual is of supreme importance in determining whether he will survive. Immaturity, atelectasis, and congenital malformations here account for nearly three-fifths of all the deaths; infections play a smaller part than later in infancy and childhood. With improvement in prenatal care it may be possible to diminish the number of premature births, but in all likelihood this category will continue to be large, particularly in comparison with those that are more directly preventable such as deaths from congenital syphilis, birth trauma, asphyxia, and postnatal infections. In the countries showing the lowest infant mortality rates for the year 1925—New Zealand, Holland, Sweden—the causes of death during the first two weeks of life were not greatly different from those found for the same period of life in other countries with comparatively high infant mortality. In all communities the first weeks of life are the period of highest mortality, because in them takes

TABLE VIII  
MORTALITY FOR SEPARATE MONTHS OF LIFE, PER 1000 LIVING BIRTHS

Month of Life	1	2	3	4	5	6	7	8	9	10	11	12	Infant Mortality Rate
United States * . . . .	44.8	8.9	7.6	7.5	7.2	6.8	5.7	5.3	5.2	4.7	3.5	4.0	111.2
Germany † . . . . .	44.1	10.4	9.4	7.8	6.2	5.3	4.7	4.3	3.8	3.4	2.9	2.7	105.2

\* Woodbury, 1915, 8 cities. † Roesle, 1925.

place the adaptation of the organism to its environment. After this period each month shows a steadily declining death rate to the end of the first year.

Figure 4 gives the infant mortality rates for New York City for a period of thirty-three years. By the term “infant mortality rate” is meant the number of deaths during a calendar year per 1000 living births during the same period. It is perfectly apparent that a decrease in the infant mortality rate has been going on progressively with only minor fluctuations from year to year. This reduction in mortality is all the more noteworthy, occurring as it did during a period in which the population of New York City practically doubled. In spite of this increase in population not only the mortality rate but the *actual* number of deaths diminished steadily.

We may obtain some idea of how this reduction has been brought about by a further examination of the data in Figure 4. The most striking diminution is in the mortality from diarrheal diseases. During the period in question the death rate from this cause decreased to one-tenth of its previous value. Infectious diseases, including those of the respiratory system, have been considerably reduced. Very little impression has been made on the mortality caused by prematurity, birth injuries and atelectasis; none at all upon the deaths due to congenital malformations.

Figure 5 gives the percentage of deaths due to different causes in 1889 as contrasted with 1929.



A comparison of infant deaths by calendar months in 1889 and 1929 is given in Figure 6. This bears further witness to the lines of attack along which public health measures have been particularly successful. In spite of the increase in the total population of New York City which took place during these forty years, the actual mortality curves from October to December and from January to May

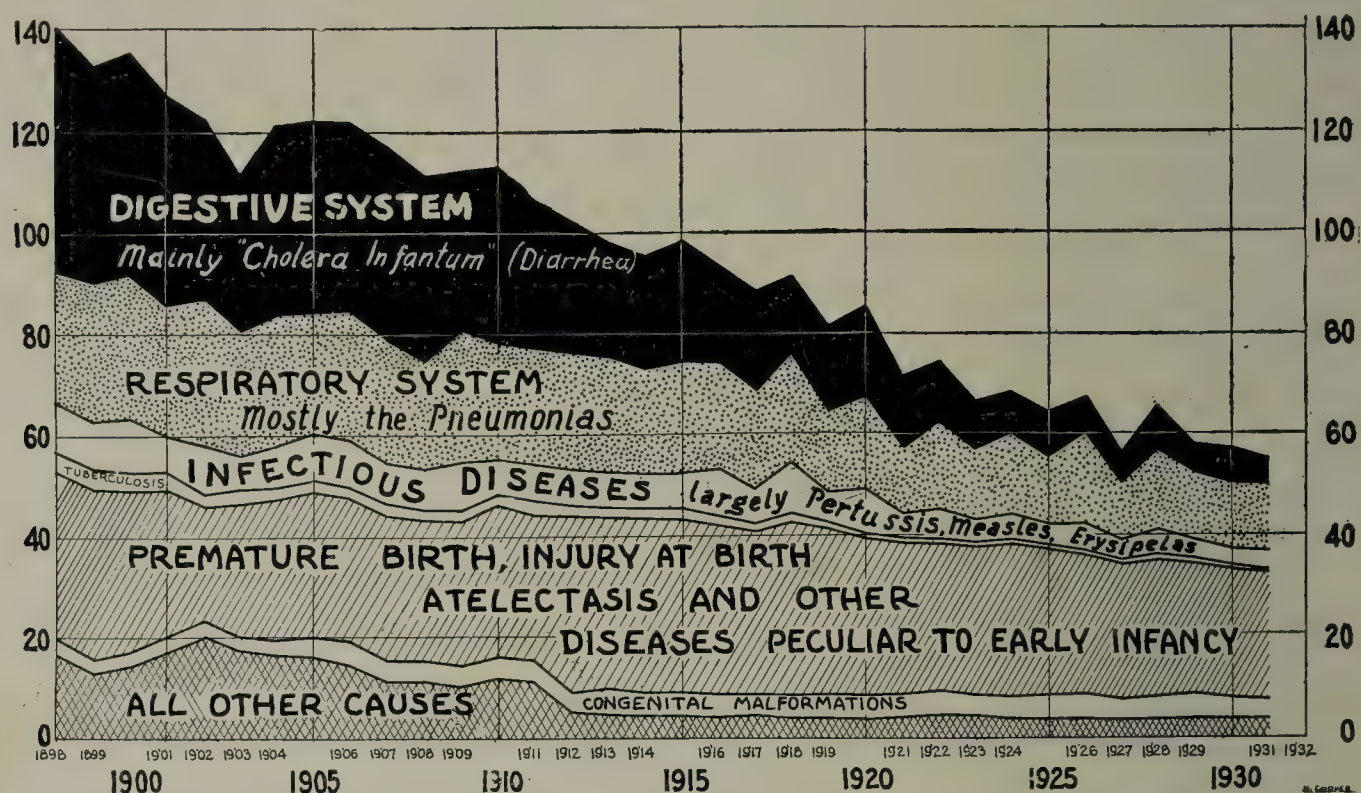


FIG. 4.—INFANT MORTALITY RATE IN NEW YORK CITY (1898-1931).  
Deaths under one year per 1000 living births.

inclusive nearly coincide; this may be taken as evidence of a general improvement in methods of infant care. The striking summer peak of infant deaths in 1889, covering the period from June to September inclusive, has been converted into a curve of relative health, owing to reduction of the excessive seasonal incidence of severe diarrhea during the summer months. Of this angle of control of infant health more will be said later in the chapter on Diarrhea.

The total deaths for all ages per 1000 of population show also a fairly steady reduction, as is seen in the accompanying chart (Fig. 7). By a comparison of the curves representing the different age groups, however, it is clear that the reduction of mortality has been much less conspicuous for the group of individuals over five years of age than for those under five. In fact, the slope of the curve of all deaths under five years is steeper than that for infants under one year. Accurate statistics for causes of death between the ages of one year and five years for a representative American population are not available, but one may infer that this improvement in conditions has been brought about by methods analogous to those which have been effective in reducing the infant mortality, namely, the prevention and control of digestive disorders and infectious diseases. It is of interest to note that during the influenza pandemic in 1918 it was the age group of individuals over five years who were most severely afflicted.

Among the influences contributing to the reduction in infant and child mortality within the last forty years may be mentioned: a wider diffusion of knowledge of infant feeding and hygiene; a great improvement in the general milk supply;



the closer supervision of infants in cities at health stations; the improvement in organization and increase of power of municipal and state public health departments; the widespread adoption of prophylactic measures directed against specific infectious diseases, particularly the protective inoculation against diphtheria; and, finally, the more recent advances in pediatrics and the more rational treatment of the sick child by the average physician.

**Sudden Death.**—This is not a very uncommon occurrence in infants who are apparently healthy. They are sometimes found dead in bed under circumstances in which grave suspicion may unjustly rest upon the attendants. This usually hap-

1889			1929	
10527 DEATHS UNDER ONE YEAR			7281 DEATHS UNDER ONE YEAR	
	percent			percent
DIARRHEAL DISEASES	31.0		PREMATURITY	25.8
BRONCHITIS AND PNEUMONIA	16.6		PNEUMONIA AND BRONCHITIS	22.3
PREMATURITY	6.9		DIARRHEAL DISEASES	10.3
TUBERCULOSIS	3.8		CONGENITAL MALFORMATIONS	8.0
WHOOPING COUGH	3.2		INJURY AT BIRTH	6.8
OTHER NEONATAL CONDITIONS *	2.8		OTHER NEONATAL CONDITIONS *	6.2
DIPHTHERIA AND CROUP	2.3		CONGENITAL DEBILITY	5.1
INJURY AT BIRTH	1.2		WHOOPING COUGH	1.2
SYPHILIS	0.9		SYPHILIS	1.2
CONGENITAL MALFORMATIONS	0.8		TUBERCULOSIS	1.0
CONGENITAL DEBILITY	0.7		DIPHTHERIA AND CROUP	0.3
ALL OTHER CAUSES	29.7		ALL OTHER CAUSES	11.7
*EXCLUSIVE OF PREMATURITY, INJURY AT BIRTH, AND CONGENITAL DEBILITY.				

FIG. 5.—CHIEF CAUSES OF DEATH IN FIRST YEAR OF LIFE IN 1889 AND 1929, NEW YORK CITY.

pens with those who are delicate or suffering from malnutrition, especially in institutions, where sudden death is by no means rare. The most frequent causes in infants are the following:

**Malformations.**—While in most cases malformations of a serious nature give rise to symptoms, these may be absent, or may be so slight as to be overlooked. Infants may succumb during the first few days of life from malformations of the heart, lungs, kidneys, stomach or intestines, and sometimes from diaphragmatic or umbilical hernia.

**Internal Hemorrhage.**—This is chiefly limited to the first two weeks of life. In the cases that have come to our notice the cause has been extensive hemorrhage into the general abdominal cavity, or intracranial hemorrhage. Such cases are reported in the chapter upon Visceral Hemorrhages in the Newly Born. Under these circumstances no symptoms may exist until the occurrence of collapse, with death in a few hours.

**Asphyxia from Aspiration of Food into the Larynx or Trachea.**—This may be due to vomiting or to the regurgitation of food during sleep; in a very weak infant it may occur while awake. This is usually seen in infants who are less than a year old, and most of the reported cases have been under six months. Such



children are usually delicate. There seems to have been vomiting with an attempt at crying, during which the food is drawn into the air passages. In some cases, as that reported by Demme, a single large curd of milk has been found in the larynx. In others, food is found in the larynx, trachea, and large bronchi. Cases have also been reported by Partridge and by Parrot, and we have met with at least six. The infants have generally been found dead in bed within a few hours after feeding. This accident is more likely to happen when an infant lies upon his back.

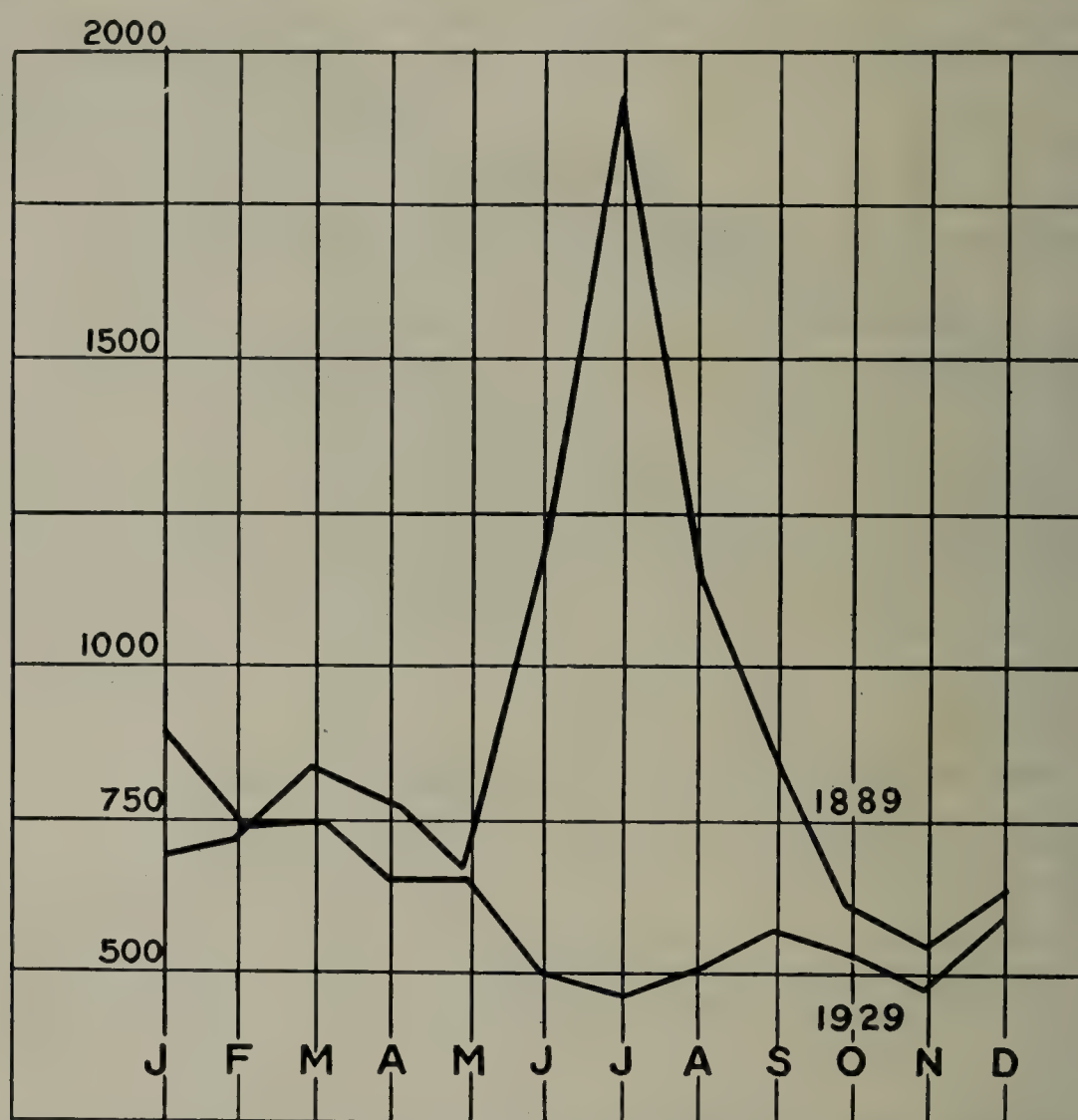


FIG. 6.—INFANT DEATHS BY CALENDAR MONTHS, 1889 AND 1929, IN NEW YORK CITY.

In infants and young children, asphyxia may result from the pressure of a retropharyngeal abscess upon the larynx or trachea, or from the rupture of such an abscess into the air passages. Previous symptoms may have been wanting. Abscesses in the posterior mediastinum connected with tuberculous bronchial nodes or caries of the spine may suddenly discharge into a bronchus. Sudden death may occur with spinal caries from dislocation of the upper cervical vertebrae. Small, feeble infants are occasionally asphyxiated when placed face downward upon bedclothes or soft pillows.

*Status Lymphaticus*.—Although these cases are very imperfectly understood, they are not rare. We see two or three each year. The condition is most frequent in infancy, but is not confined to this period. When a child is suffering from some minor illness, often bronchitis, severe attacks of asphyxia may develop and sometimes convulsions may unexpectedly occur and death soon follow. Or the child may die in convulsions without any special antecedent symptoms. Sometimes sudden death follows the administration of an anesthetic. In most cases there is



found besides an enlarged thymus, a general hyperplasia of lymphoid tissue throughout the body. The possible relation between the thymus and sudden death in these cases is more fully discussed elsewhere.

*Atelectasis.*—In very young infants there may be no symptoms noticed except those of general malnutrition until sudden death occurs, sometimes with convulsions and sometimes without any such symptoms. (See Atelectasis.)

*Malnutrition.*—In this class of cases sudden death is of common occurrence. These children are often apparently as well two or three hours before death as for several weeks. Death may occur at night, the children being found dead in bed

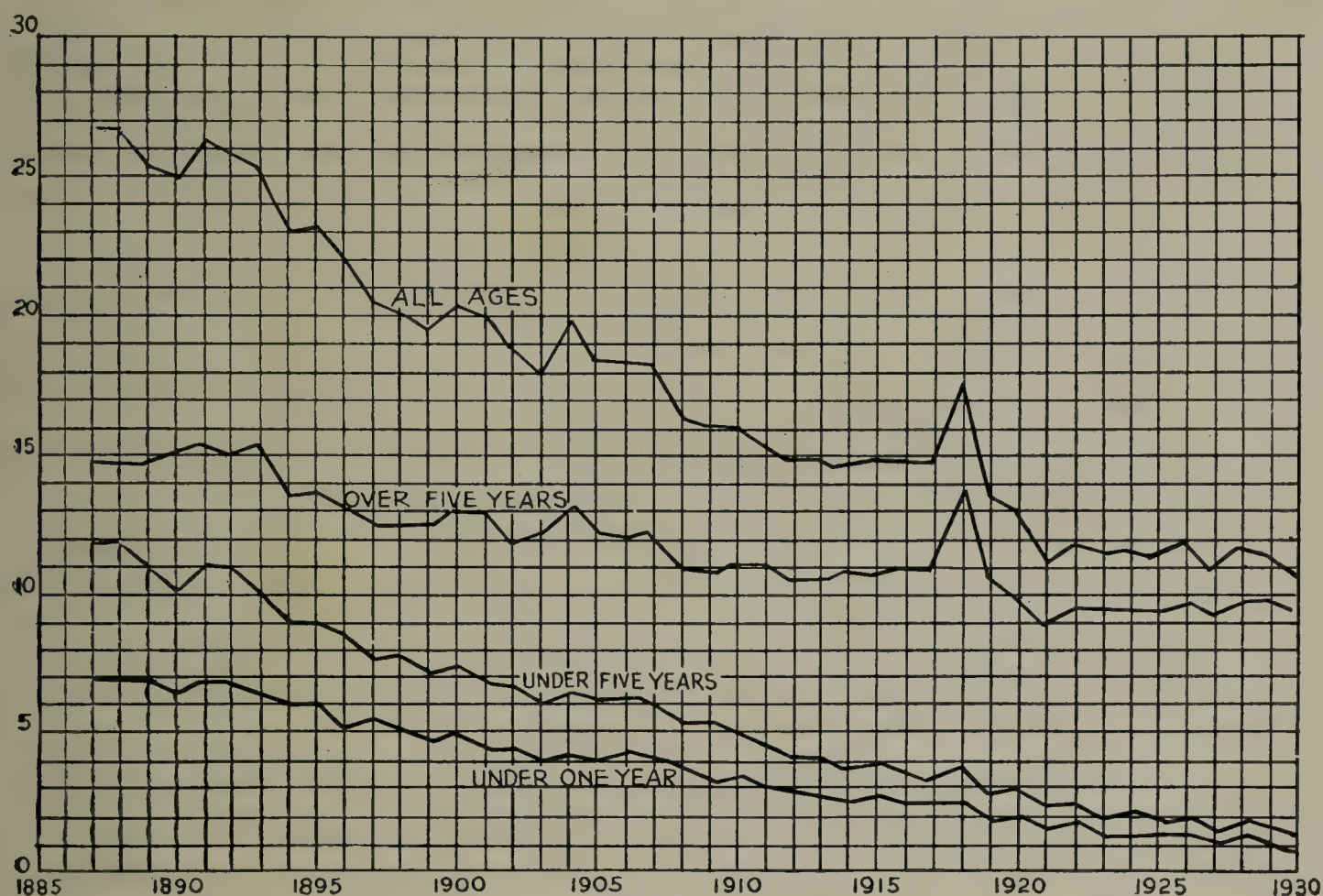


FIG. 7.—DEATHS PER 1000 OF POPULATION IN NEW YORK CITY, 1887 TO 1930.

in the morning. In some of the cases the exciting cause seems to be the lowering of the temperature, while in many no exciting cause can be found; the vital spark simply goes out after burning for some time with a feeble flame. In some of these cases the autopsy reveals atelectasis, but in many cases nothing abnormal is found, death apparently resulting from circulatory failure.

*Death after a Few Hours' Illness Characterized by High Temperature.*—This is not an uncommon occurrence. Infants apparently well may be taken with great prostration and a high temperature, which may rise rapidly to  $106^{\circ}$  or even  $107^{\circ}$  F., and death follow in from six to twelve hours, sometimes preceded by convulsions. These are often examples of acute septicemia, most frequently from a pneumococcus, sometimes from a streptococcus, or other organism. In older children death may be due to malignant scarlet fever or epidemic meningitis; however, unless these diseases are prevailing epidemically, it is hazardous to make such a diagnosis without the evidence of a positive blood culture.

The occurrence of sudden death from heart failure after diphtheria, with pleurisy with effusion, or with carditis will be discussed elsewhere.



### CHEMICAL RELATIONS IN CHILDHOOD

The maintenance of life depends upon a series of physicochemical processes controlled by balanced equilibria. Of a few of these we possess a knowledge sufficiently comprehensive to make clinical applications possible. Only such as are the direct concern of the pediatrician will be discussed in the present work.

**Acid-base Equilibrium.**—The normal human body contains an excess of base; its alkalinity is preserved at an extraordinarily constant level, even though there is a steady production of acids by the processes of metabolism. This constancy of reaction is maintained by the presence of buffer substances in the body fluids of which the carbonates, proteins and phosphates are the most important, and by certain regulatory mechanisms which enable the body to rid itself of its acid metabolic products with greater or less rapidity, or in varying quantity as conditions may demand. The elimination of acid is accomplished by a threefold mechanism:

1. Carbon dioxide is given off from the lungs in amounts which vary to a certain extent with the needs for acid excretion.

2. The kidneys are able to excrete an acid urine from an alkaline blood. Organic and mineral acids are eliminated in the urine, but, unlike the lungs, this excretion cannot be accomplished without the loss of some base. Under normal conditions the base so lost is almost entirely mineral base, but when excessive amounts of acid are to be excreted a further mechanism comes into play which operates to spare the mineral base of the body:

3. The kidney forms ammonia from urea and this ammonia is used in partially neutralizing the excess of acid to be eliminated.

It is possible that in addition to the above mechanisms the body may be able to some extent to maintain its acid-base balance by the selective absorption of acid or basic radicals from the intestine, or by reëxcretion into the intestine, but such a mechanism has not as yet been clearly demonstrated.

Disturbances of the normal acid-base equilibrium may arise in a variety of ways, and may lead either to acidosis or alkalosis. Of those which tend to produce acidosis we may distinguish between physiological and pathological causes.

Under conditions of violent exercise sufficient lactic acid may be liberated to lower the pH of the blood considerably. Such a physiological acidosis is, however, very transitory.

Of the pathological causes of acidosis we may distinguish several groups:

1. Conditions in which an abnormal production of acid occurs in the body. The most notable of these is diabetes mellitus in which the ketone acids, diacetic and beta-oxybutyric, as well as acetone are produced in excessive quantities. A similar "acetone body" acidosis is associated with starvation and with many cases of recurrent vomiting. An acidosis due to excessive production of lactic acid has also been observed.

2. Conditions in which the removal of carbon dioxide from the lungs is impaired may lead to acidosis. Thus it may be found with extensive pulmonary disease of any kind.

3. Interference with the normal elimination of acid by the kidney. As with



adults, any type of renal disease which impairs the kidney function may lead to acidosis. The most important cause in infancy, however, is dehydration, which may cause either a partial or complete suppression of urine. Such dehydration is likely to occur either in newly born infants who are not receiving adequate amounts of fluid, or in infants suffering with diarrhea.

4. A fourth cause of acidosis is the excessive loss of mineral base from the body. This occurs by the intestines, when there is severe diarrhea.

Among the causes of alkalosis there may be considered both physiological and pathological. The "alkaline tide" which occurs after meals owing to the secretion of hydrochloric acid into the stomach has long been recognized with adults, but has only recently been observed with children. With breast-fed infants this has not been detected, but with infants fed on cow's milk, a food of higher buffer value which demands the secretion of a larger amount of acid, it is often recognizable.

The pathological conditions which produce alkalosis are those in which there is an excessive loss of acid from the body, either from the lungs, when there is overventilation, or from the stomach when there is vomiting. Overventilation of the lungs may occur with prolonged crying, but it is doubtful if this ever reaches significant proportions. With certain organic diseases of the brain, however, notably epidemic encephalitis, persistent overventilation may occur and a marked alkalosis result.

Any condition in which there is severe vomiting may result in the loss of sufficient acid in the gastric secretions to lead to alkalosis. The two most important causes are pyloric stenosis of infants and the vomiting which accompanies pertussis.

Alkalosis often results from the administration of alkali for therapeutic purposes. This is particularly likely to occur when the kidney function is impaired and an excess of alkali cannot readily be eliminated.

The recognition of acidosis and alkalosis has become increasingly simple with the laboratory methods that have been developed in recent years. There is only one reliable clinical evidence of acidosis and that is hyperpnea—exaggerated breathing. It is usually, but not invariably, present. The respirations are deep. They may be and often are increased in frequency but they are not rapid and panting. In its pronounced forms hyperpnea is easy of recognition. Milder grades may escape detection because an infant is restless and active. At times information can be gained from the color of the mucous membranes. With acidosis the lips may present a cherry-red appearance. The laboratory tests by which acidosis may be recognized are: (1) The elimination of excessive amounts of ammonia and organic acids in the urine. These findings are, however, not always present and they are not to be altogether relied on. They may be absent in many types of acidosis; furthermore, the presence of acetone bodies in the urine, even in considerable amounts, does not necessarily indicate an acidosis. (2) The determination of the bicarbonate or the carbon dioxide combining capacity of the serum or plasma by the methods of van Slyke. (3) The direct determination of the pH of the serum or plasma by electrometric or colorimetric methods.

Alkalosis produces no constant symptoms. At times the breathing is found to



be slow and shallow; or the increased alkalinity of the blood may affect indirectly the calcium metabolism and thus lead to the development of tetany. Alkalosis may be recognized either by the determination of the carbon dioxide combining power of the plasma or serum, or by direct determinations of the hydrogen ion concentration.

It has been customary to distinguish between compensated and uncompensated acidosis and alkalosis; the term compensated being used to describe a condition in which the alkaline reserve of the body was altered, as evidenced by an altered carbon dioxide-combining capacity of the serum, while the hydrogen ion concentration itself was unaltered. In the uncompensated type the hydrogen ion concentration itself was affected. It would seem, however, that this distinction is purely arbitrary. For even in the milder forms of so-called "compensated" acidosis or alkalosis there is probably a shift in the pH, but so small as to escape detection by ordinary methods.

The treatment of acidosis and alkalosis is described in connection with the various conditions with which they are associated.

**Electrolyte Equilibrium.**—A somewhat broader conception of the acid-base equilibrium is obtained by studying the total electrolytes of blood plasma. The notation usually employed is that introduced by Gamble, which is illustrated in the accompanying figure. The cations and anions of the plasma are arranged in parallel columns, the height of which denotes equivalent concentrations; the cations are superimposed upon each other in the left-hand column, and the anions on the right hand. Since the plasma must under all conditions be electrically balanced, the two columns are of equal height. The normal value for the total concentration of either cations or anions is approximately 156 milli-equivalents per liter. Each of the ions present may vary independently, its concentration being determined by particular factors. Although it is common usage to speak of particular cations and anions as *bound* to each other, this does not represent the actual state of affairs; it would be more correct to speak of anions as being *balanced* by cations and *vice versa*.

In pathological conditions, particularly those associated with acidosis or alkalosis, a study of the plasma electrolytes may throw light on the nature of the disturbance. The determination of the plasma electrolytes does not provide a measure of the reaction of the plasma. An alteration of the plasma reaction is, however, reflected in the concentration of bicarbonate; in conditions of acidosis the bicarbonate is decreased, while in alkalosis it tends to increase. This follows from the constancy of the relation:

$$\frac{H^+ \times HCO_3^-}{H_2CO_3} = K, \text{ which may be written } H^+ = K \frac{H_2CO_3}{HCO_3^-}$$

The hydrogen ion concentration of the plasma is seen to depend upon the ratio:  $\frac{H_2CO_3}{HCO_3^-}$ . Pathological conditions which affect this ratio will alter the hydrogen ion concentration, and, conversely, any factor which alters the hydrogen ion concentration of the blood will affect the  $\frac{H_2CO_3}{HCO_3^-}$  ratio. Acidosis, an increase in  $H^+$  ions,



will cause the combination of  $H^+$  and  $HCO_3^-$  ions to form  $H_2CO_3$ ; the concentration of bicarbonate is thereby reduced. Alkalosis, a condition in which  $H^+$  ions are reduced, will cause  $H_2CO_3$  to dissociate into  $H^+$  and  $HCO_3^-$  ions, bringing about an increase in plasma bicarbonate.

The unique rôle of bicarbonate in maintaining the electrolyte equilibrium of the plasma has been emphasized by Gamble in particular. Owing to the constant presence of free carbonic acid in the plasma, bicarbonate will increase whenever fixed base is left unbalanced by other acid radicals; this occurs when acid is lost from the body or if excess alkali is administered. Conversely, when base is lost or other acid radicals accumulate in the body, bicarbonate, being the radical of a weak acid, will be dispossessed of its base and converted into free carbonic acid.

Figure 8 illustrates some of the more common alterations of plasma electrolytes which are encountered in children.

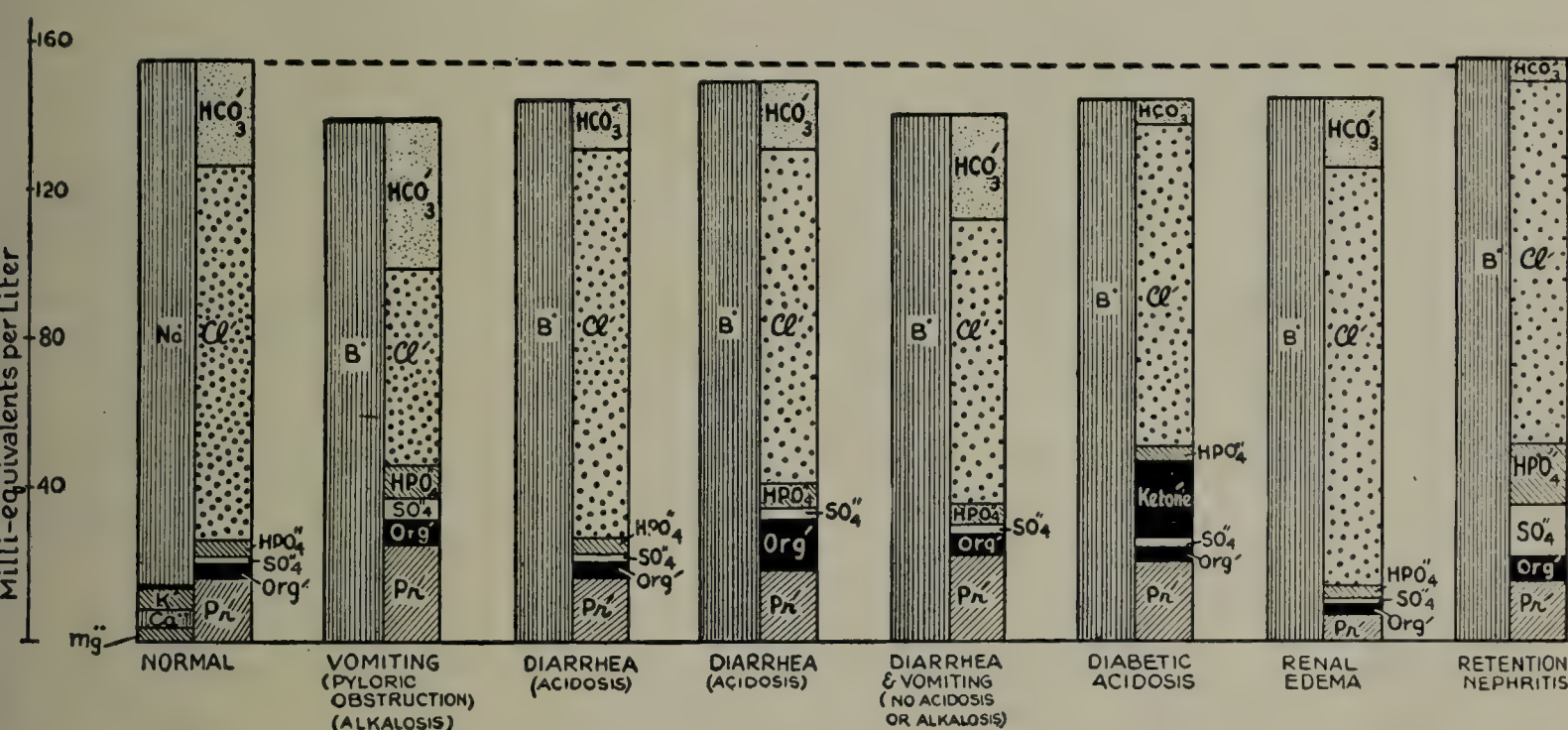


FIG. 8.—PLASMA ELECTROLYTE PATTERN IN VARIOUS PATHOLOGICAL CONDITIONS.

*Vomiting from pyloric obstruction* is characterized by loss of the gastric secretions from the body. Alkalosis results because of the loss of hydrochloric acid. Although a certain amount of base is lost in the gastric secretions, the loss of chloride by this route is four or five times as great as that of base. It is not surprising, therefore, to find a moderate diminution in total base, but a much more marked reduction in the chloride of the plasma. This is compensated for by an increase of bicarbonate and of the other plasma anions. Under normal conditions approximately 60 per cent of the total base is balanced by chloride, but with pyloric obstruction the percentage of base which is so bound may be as low as 35 per cent.

The first of these two diagrams illustrates the more common type of alteration caused by *uncomplicated diarrhea*. It will be noticed that an acidosis is present; the plasma bicarbonate is diminished and an unusually large proportion of base is balanced by chloride. This condition has been termed a "chloride acidosis"; the term is, however, misleading, in so far as it suggests that a relative abundance of chloride is the primary factor at fault. Such an acidosis actually results from an



excessive loss of base as compared with chloride in the diarrheal stools. The various intestinal secretions are alkaline; they contain more fixed base than chloride; with active peristalsis these are lost from the body and the blood plasma is depleted of base. Were it not for certain compensatory factors, both the total base and the chloride would be found greatly reduced, the former more so than the latter. However, when large amounts of water and electrolyte are lost by the body, two compensatory mechanisms come into play. Fluid from the tissue spaces is poured into the plasma and there may also be a reduction in the circulating blood volume. These factors tend to replenish and to conceal the loss of electrolyte; compensation may go so far that the total electrolyte of the plasma rises above the normal figures. Even so, the anion pattern retains its characteristic features; a *relatively* low base as compared with chloride bears witness to the excessive loss of base from the body.

A second type of disturbance is sometimes seen with *uncomplicated diarrhea*. Here the proportion of base balanced by chloride may be quite normal. There is, however, a notable increase in the concentration of organic acids (chiefly lactic acid) together with some increase in the amount of phosphate and sulphate. Dehydration and the resulting suppression of urinary secretion are responsible for these changes. Impairment of the circulation results in the formation of lactic acid and renal retention causes the accumulation of phosphate and sulphate in the blood. The acidosis is due to abnormal acid production and to failure of normal acid excretion.

It is not uncommon to find cases of acidosis which cannot be so sharply classified. The three factors—loss of base, abnormal acid production and inadequate renal excretion of acid may all play a part in a given instance.

*Diarrhea accompanied by vomiting* gives a picture which is a combination of those caused by the two conditions independently. The abnormal loss of base in the intestinal secretions may be exactly compensated for by excessive loss of acid in the gastric secretions. As a result neither acidosis nor alkalosis results. Evidences of dehydration and of inadequate renal function will usually be present, however; protein, phosphate, sulphate and organic acid are likely to be somewhat increased.

The acidosis of *diabetes* is distinguished by the presence of ketone acids which replace much of the plasma bicarbonate. A ketone body acidosis may, however, occur in conditions other than diabetes. It may result from starvation or from a diet relatively low in carbohydrate; it is often found in association with acute infections and in other pathological conditions in which absorption and mobilization of carbohydrate may be faulty.

The electrolyte changes in *renal edema* are characteristic. The most striking change is a reduction in plasma protein, due apparently to loss of albumin through the kidney. Associated with this there is a reduction of total base and an increase of chloride; bicarbonate is often somewhat diminished. The picture is that of a "chloride acidosis," but one should not conclude that retention of chloride is at fault. The excretory power of the kidney is usually unimpaired; the interpretation of the electrolyte changes is not altogether clear, but they appear to be secondary to the reduction of plasma protein.



*Retention nephritis* may bring about an extreme acidosis, owing to the inability of the kidney to excrete an acid urine as under normal conditions. Phosphate and sulphate in particular accumulate in the blood in quantities greatly in excess of the normal; the high concentration of these two anions is the most characteristic feature of the electrolyte picture. Total base and chloride may be somewhat increased. The picture is not infrequently complicated by vomiting.

Complete studies of the plasma electrolytes are seldom undertaken in young children, for the quantity of blood required is under most circumstances prohibitive. Observations of this kind are of comparatively little diagnostic value, since the diagnosis can usually be obtained by simpler means. The chief value of electrolyte studies has been in indicating the most suitable types of replacement therapy.

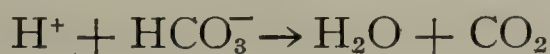
**Osmotic Equilibrium.**—Intimately related to the acid-base equilibrium and to the electrolyte equilibrium in the body is the osmotic equilibrium. The isotonicity of the body fluids which is essential to life is normally maintained within narrow limits, although the intake of water and dissolved particles may vary widely.

Organic substances play a very minor part in maintaining osmotic pressure. Their molecules and ions are of large size and are correspondingly few in number. Hence it is almost entirely the small particles of inorganic substances which are responsible for the tonicity of the body fluids. These small particles are only in part ingested as such; a very considerable part results from the breaking down of large molecules into small ones which occurs during digestion and in physiological oxidations.

As in the case of the acid-base equilibrium, regulation is accomplished largely if not entirely by the excretory mechanisms of the body rather than by selective absorption from the intestine. Thus, of the three components which are most important in regulating the osmotic equilibrium—water, sodium ions and chloride ions—the intestine normally absorbs more than 90 per cent of the intake.

Loss of water and electrolyte takes place through the lungs, the skin and the urine. It is claimed that certain heavy metals like calcium and iron are normally excreted in the intestine but these are quantitatively of little significance as far as osmotic equilibrium is concerned. Under pathological conditions, however, excretion of water and electrolytes into the intestine may assume great importance.

Through the lungs carbon dioxide and water are constantly being lost. The carbon dioxide represents a loss to the body fluids of electrolyte in the form of  $\text{H}^+$  and  $\text{HCO}_3^-$  ions, since it is liberated from the lung capillaries by the reaction:



The ratio of water to carbon dioxide in the expired air varies slightly with different atmospheric conditions and with different conditions of pulmonary ventilation, but the loss of electrolyte so brought about is always very much greater than the loss of blood water. The result of pulmonary ventilation is therefore a dilution of the blood and a diminution of its osmotic pressure. With excessive ventilation this effect is, of course, more marked. The increased ventilation associated with exercise is of great importance in this connection, for unless this mechanism existed



for removing the excessive carbon dioxide produced, bicarbonate and hydrogen ions would accumulate in the blood according to the reaction:



and the osmotic pressure of the blood would rapidly rise.

The secretions of the skin have not as yet been adequately studied in regard to their effect on osmotic equilibrium. The lungs, as has been pointed out, serve almost exclusively as the path of excretion for the excess of endogenous electrolyte produced by the body, but they are of little assistance in correcting an unbalanced intake of salts and water. This latter adjustment must be accomplished by the kidney, which is able to secrete either a hypertonic or a hypotonic urine as conditions may demand.

The proportion of water and salts ingested by individuals upon a mixed diet is subject to wide normal fluctuations which are reflected in the composition of the urine. The milk-fed infant, on the other hand, receives a diet which is practically isotonic; comparatively little adjustment is necessary to maintain his osmotic equilibrium. It is by no means necessary, however, for the infant that this should be the case, for he is quite capable of maintaining his osmotic equilibrium in the face of wide variations of intake.

The osmotic pressure of the urine shows wide fluctuations throughout the day. It is, of course, influenced by the demands for excretion of water by other routes. When followed for a longer period, however, these variations tend to disappear and the average osmotic pressure of the urine tends to approach that of the diet. Most adults ingest relatively little water as compared with salt; their urine is therefore usually hypertonic. The infant's urine, however, is usually somewhat hypotonic.

The mechanisms which regulate osmotic pressure may be disturbed in a variety of ways—by highly abnormal intakes of water and salts, by abnormal secretions or excretions from the body and by pathological conditions which interfere with the pulmonary or renal elimination. The changes may be either in the direction of hypertonia or hypotonia. An altered osmotic condition of the blood may be compensated for by the mobilization of extracellular tissue fluid into the blood stream, which, being of normal tonicity, tends to restore the normal osmotic pressure.

Measurements of the osmotic pressure of the blood serum in children have been made by the freezing point method by Buckman, Darrow, Hartmann, Schönthal and others. Expressed in terms of concentration of dissolved particles, the normal variations are from 300 to 330 osmolar millimols. In pneumonia, renal edema and other conditions characterized by lowering of the plasma electrolytes the osmotic pressure may fall as low as 275 osmolar millimols or even less. In advanced chronic nephritis with extreme nitrogen retention it may rise well above the normal. Schönthal observed an osmotic pressure of 380 osmolar millimols in such a case.

It is not possible to relate particular symptoms to disturbances of osmotic pressure. The conditions in which abnormal values are found are complex; many other factors are pathologically altered. Unquestionably, osmotic forces play an important part in regulating the passage of water through the body and its distribution in the various tissues. It has been maintained that edema and dehydration represent



adjustments of body fluid to a retention or loss of electrolytes, these adjustments tending to preserve the normal osmotic pressure of the blood. With our present knowledge it is not possible to explain the phenomena of water transport on a purely osmotic basis, for other forces unquestionably are concerned here.

The foregoing are only a few of many physicochemical equilibria upon the maintenance of which the survival of the organism depends. Apart from these mechanisms nearly every substance concerned in metabolism must be rigidly controlled as regards concentration in various parts of the body, if health is to be preserved. The metabolism of individual chemical substances is discussed under Nutrition.

## GENERAL CONSIDERATIONS OF IMMUNITY

**Resistance to Infectious Disease.**—So far as it is understood, resistance depends on two important mechanisms: (1) the development of circulating antibodies, many of which are highly specific, and (2) certain protective responses on the part of the tissue cells. There are doubtless other factors grouped under the vague term "general resistance" which are not clearly understood. Of the cellular responses, some, like the ingestion of bacteria by leukocytes, are nonspecific, while others, such as the responses obtained with protein hypersensitiveness, are highly specific. The relation of allergy to immunity is still an open question; it is not clear whether sensitization is beneficial or detrimental to the organism as a whole; possibly there are conditions in which it is of value and circumstances in which it is harmful. It is not within the scope of this work to discuss the general problems of immunity, but rather to point out certain peculiarities exhibited by children in their immunological reactions.

**Passive or Natural Immunity.**—The immunity of the newly born infant to certain diseases is very striking. Scarlet fever, measles, rubella, diphtheria, mumps, rheumatic fever, influenza, poliomyelitis and infectious jaundice are almost unknown in early infancy. In the rare cases recorded the mother has usually been suffering from the disease at the time of confinement. The duration of this neonatal immunity is variable. With scarlet fever, measles and rubella it is about six months. With mumps it is longer, this disease being rare before the third year. Rheumatic fever is decidedly uncommon before the third or fourth year, and epidemic influenza showed a striking tendency to spare young infants in the pandemic of 1918.

Immunity of the newly born may be a passive immunity, antibodies being obtained from the mother either through the placenta or through the colostrum. Another possibility is that this immunity is a natural one; the infant does not contract the disease because his tissues are not sufficiently differentiated to exhibit the response characteristic of the disease. Passive transfer of antibodies through the placenta seems to be the explanation of the immunity in the case of diphtheria. It has been shown that diphtheria antitoxin passes readily through the placenta. The infant is Schick negative only when the mother reacts negatively; since the great majority of adults are Schick negative and therefore contain antitoxin in their blood, the majority of infants are similarly protected. Like all passive immunity, this is of short duration, lasting only from six months to a year.

Transfer of antibodies by means of the colostrum has not been conclusively



demonstrated<sup>1</sup> for the human species, but is known to occur with cattle. Theobald Smith and his coworkers have shown that the newly born calf is protected from severe colon bacillus infections by antibodies present in colostrum. The fact that human colostrum, like that of the cow, contains an abundance of euglobulin suggests that a similar mechanism may occur in man. It is known that many antibodies are closely associated with euglobulin.

The immunity of the young infant to measles appears to be a passive immunity obtained from the mother, although it is not known whether the transmission is placental or through the colostrum. It has been shown that infants are immune to measles only if their mothers have had measles.

The immunity to scarlet fever, on the other hand, appears to be due to an inability of the child's tissues to react in the characteristic way. The immunity in this case is more apparent than real, for the infant is susceptible to infection with scarlatinal streptococci, even though he does not exhibit the cutaneous and renal manifestations of scarlet fever.

In contrast with the diseases mentioned above, there are many others against which the newly born infant has no particular protection. Pertussis, tuberculosis, syphilis and the common pyogenic infections belong in this group. Such immunity as occurs with these diseases must be acquired.

**Acquired Immunity.**—After the immunity of the newly born has disappeared, and with diseases in which no such immunity occurs, protection can as a rule be purchased only at the price of an attack of the disease. With many diseases a single attack produces lasting immunity. Such is the case with measles, scarlet fever, rubella, chicken pox, smallpox, mumps, typhoid and paratyphoid, pertussis and poliomyelitis. Second attacks of any of these diseases are exceedingly rare. With certain other diseases, such as diphtheria, meningococcus meningitis and the common cold, immunity following an attack is not to be counted on.

Another type of acquired resistance is seen in the case of chronic diseases like syphilis or tuberculosis, where the presence of the disease in a latent form confers complete or partial protection against reinoculation.

There are certain diseases to which immunity may be acquired during the course of life, without evidence of an attack of the disease. This seems to be the case not infrequently with diphtheria and scarlet fever, and also with poliomyelitis. In such instances it seems likely that the immunity is produced by the presence of the infectious agent, but that the attack of the disease is so mild or so atypical that it escapes attention. It is unlikely that antibodies appear with increasing age unless they are induced by the presence of some specific antigen.

The active and passive immunity which can be conferred by special prophylactic measures will be discussed in connection with the particular diseases in question.

In regard to the common pyogenic infections, the young infant, as has already been stated, possesses no special protection; his resistance against them must be acquired. Soon after birth the child comes into contact with pathogenic organisms of many varieties. These organisms are apparently too few in number to cause

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<sup>1</sup> The Widal reaction has been obtained with the milk of mothers convalescent from typhoid, and also with the blood of their infants, which suggests that this is an example of passive transfer of antibodies by the milk.



disease, yet sufficient to cause the body to react and to develop resistance. Although detailed information about this is wanting, there is reason for believing that, as age increases and the contacts with submorbid doses of bacteria increase, the resistance of the individual gradually rises. The younger the infant, the more likely he is to meet an overwhelming infection. In the newly born infant, infections of the respiratory tract or the umbilicus which are apparently mild terminate not infrequently in a fatal septicemia. It is characteristic of pyogenic infections up to the third or fourth year that the regional lymph nodes are involved with greater frequency and severity than in later life. Infections of the pharynx all too commonly give rise to marked inflammation and suppuration of the cervical and retropharyngeal lymph nodes.

As in the adult, resistance to disease is subject to fluctuations related to the general health of the individual. This process is not well understood. There is some evidence that dietary factors, particularly vitamins, may exert an influence.

The newly born infant shows certain serological peculiarities. Comparatively few specific group hemagglutinins are found in the blood at birth. In congenital syphilis it is usual to find a negative Wassermann reaction at birth, this reaction becoming positive only after several weeks or months. These observations suggest that the infant's ability to form antibodies may not be fully developed at birth; this may be a factor in rendering him more susceptible to infection.

The tissues of the young infant may react in ways which are not seen in later life. Thus, even a mild catarrhal inflammation of the larynx may induce a spasmodic contraction of the muscles of that organ, causing croup. A mild bronchitis may induce extensive spasm of the bronchial musculature; on the other hand, bronchial spasm associated with cardiac insufficiency ("cardiac asthma") is extremely rare in children suffering from decompensation.

Reactions following transfusion and intravenous arsphenamine are seen far less frequently in children than in adults, whatever the correct explanation of these phenomena may be.

Allergic manifestations are relatively infrequent in the newly born child, although a high degree of protein hypersensitiveness is occasionally seen. Such instances are attributed to transmission of the antigen by means of the placenta. After birth, as the opportunities for contact with foreign proteins increase, hypersensitiveness becomes more frequent. In infancy its manifestations are usually confined to the skin and the digestive tract; asthma and hay fever are rare before the third or fourth year. It is possible that late development of allergy will explain some of the characteristics of certain diseases in childhood as contrasted to later life.

The various diagnostic and therapeutic immunological procedures employed in pediatrics will be considered in connection with the diseases to which they apply.

## GENERAL THERAPEUTIC MEASURES

**Rest.**—The importance of this factor in the management of acute illness cannot be overemphasized. A sick infant will usually accept and profit by all the rest that is given him. Injudicious attempts on the part of the family or nurse to divert him, or to arouse him "just to see how he is getting along," are equally to be deplored.



The physician is likely to err on the side of an overzealous therapeutic campaign. During convalescence, especially with older children, quiet diversions, such as reading aloud, may be beneficial. The special stress laid on rest in chorea, rheumatic heart disease and other particular conditions will be dealt with when those diseases are separately discussed.

**Diet.**—This is a matter of signal importance. The digestive capacity is markedly impaired in parenteral disease as well as in primary disorders of the gastro-intestinal tract. Fever alone may reduce the digestive secretions and produce disturbances of motility in the gastro-intestinal tract. The blood sugar curve shows an abnormal response to the administration of glucose, and the frequent association of ketosis with fever, particularly in children, bears witness to a disturbance of fat metabolism. The organism rebels at feedings which were formerly well tolerated, by vomiting, diarrhea, or distention. Digestion is particularly likely to be disturbed at the onset of an acute disease. This may be very transitory, lasting but a few hours; on the other hand, quite commonly some disturbance of digestion remains throughout the course of an acute illness. Occasionally, the digestive incapacity persists for a long period of time, giving rise to some of the most difficult nutritional problems with which the physician has to deal.

A prompt reduction in the diet is indicated in all cases of acute disease. The traditional purging may well be omitted. Limitation of the intake is often accomplished automatically by failure of the appetite. This is particularly true of breast-fed infants. The appetite cannot always be relied on, however. It is a wise rule with bottle-fed infants to replace half of the usual feeding with water. Skimmed milk may replace whole milk. With older children the diet should be restricted to one which is almost fat-free: fruit juices, broths, breadstuffs, cereals and skimmed milk may be allowed. No general rule can be given for the duration of this dietary restriction. In diseases of short duration it is usually wise to proceed cautiously until the illness is over. Return to a normal diet should always be made gradually. The management of the various chronic disturbances of nutrition is considered elsewhere.

**Administration of Fluids.**—The replacement of fluid loss is called for in any acute illness. In fever from any cause there is increased evaporation from the skin and lungs. Large amounts of water may be lost with vomiting and diarrhea. In infancy the depletion of body fluid may be rapid and of severe degree; dehydration is especially common at this age.

*Oral Administration of Water.*—Most infants will readily take water from a bottle, particularly when small amounts are offered at frequent intervals rather than large amounts at one time. Many breast-fed infants who have not yet made the acquaintance of the bottle and rubber nipple refuse it emphatically; sometimes they can be fed with a spoon or medicine dropper. As a rule, plain water is best, but there is usually no objection to sweetening the water by the addition of cane sugar, glucose, or a maltose preparation: a 5 per cent solution may be used. Sometimes, even in the case of infants, large amounts of fluid can be administered in the form of diluted orange juice; other fruit juices seldom succeed as well. It was at one time a common procedure to sweeten water with saccharin; this was associated with the conviction that the administration of carbohydrates induced diar-



rhea, a view no longer implicitly held. We have seen some infants who appeared to prefer a salted water, made up as Ringer's solution in half physiological strength, to ordinary tap water or 5 per cent glucose solution; one can only surmise that this preference represented an actual need of inorganic material. In the case of bottle-fed infants, liberal dilution of the feedings offers the double advantage of reducing the intake of food and increasing the intake of water. The administration of water by mouth in acute illnesses is not apt to be overdone.

In older children large amounts of water can be given by mouth with skillful nursing. The variety of disguises in which water may be clothed is greater—fruit juices, lemonade and orangeade, clear broths, ginger ale, carbonated water, gelatin pudding. Here it is particularly important to keep in mind that small amounts offered frequently will net a larger intake than large amounts at longer intervals. With severe vomiting, the quantity that can be tolerated at one time may be only as much as a teaspoonful; but even under these conditions it is often possible to maintain an adequate fluid balance by the oral route alone. In the presence of nausea, fluids are sometimes better borne when given ice-cold.

*Nasal Drip.*—When oral administration of water fails to meet the demands, it can be supplied gradually and in fairly large quantity by means of a nasal catheter (size 8 or 10, American scale) introduced through a nostril and reaching about half-way down the esophagus. The catheter should be held fixed by adhesive tape to the cheek, and between it and the fluid reservoir is interposed a Murphy drip tube and screw clamp with which to observe and regulate the flow. Most infants will tolerate about 15 drops per minute, amounting to 45 to 60 c.c. ( $1\frac{1}{2}$  to 2 ounces) an hour. Feedings may be given by mouth without removing the tube, or may be injected through the tube. It is a good rule to wash the stomach out prior to passage of the catheter for nasal drip. Occasionally, persistent vomiting interferes with the use of this method of fluid administration. The tube should not be left in place more than half a day at a time, and should ordinarily be removed at night. If left in place too long it causes ulceration of the mucous membrane of the nose and esophagus, and we have seen cases in which its use was associated with the extension of thrush into the esophagus as shown at postmortem examination. It is not to be recommended for infants who are larger than a normal one-year-old child.

*Rectal Administration of Fluids.*—In some older children who have strong voluntary control of the sphincters, fluid can be administered by rectum in the form of small enemata which are retained. In the majority, however, this fails on account of reflex expulsion before any material quantity has been absorbed. If a small catheter is used which does not of itself offer too strong a rectal stimulus—the same size as used for nasal drip or a little larger, introduced eight or ten inches—and if the rate of fluid flow is regulated with a Murphy drip window and screw clamp at about 50 drops a minute, considerable amounts of water can be given successfully. Tap water is the most suitable fluid; normal salt solution and 3 per cent bicarbonate solution, formerly popular, do not favor rapid absorption on account of their osmotic pressure; 5 per cent glucose solution, although isotonic, often appears to be absorbed with greater rapidity than normal salt solution. At times glucose given in this way apparently causes an undesirable degree of abdom-



inal distention. The success of rectal administration of fluid depends to some extent on the degree of dehydration at the moment: if the need for fluid is great, it is more likely to be retained.

*Hypodermoclysis.*—When more rapid and direct methods must be resorted to, hypodermoclysis is very effective, particularly in the treatment of infants. The apparatus consists of a reservoir in which the fluid can be kept warm and sterile, connected by rubber tubing to a hypodermic needle of about 20 gauge. Normal salt solution (0.9 per cent) is most frequently used; 5 per cent glucose, or a mixture of salt and glucose solutions, is sometimes given in this way. Ringer's solution appears to offer no marked advantage. Sodium bicarbonate solutions are best not given by this route. With the patient restrained in a suitable position, the needle is inserted into the subcutaneous tissues of the back, chest, abdomen, or thighs and held in place with a strip of adhesive tape. The rapidity of flow may be regulated by raising or lowering the reservoir. The rate of absorption depends on the fluid requirements of the patient and to some extent on the vigor of his circulation. The tissues of most infants will tolerate 50 c.c. of fluid per kilogram (about 20 c.c. per pound) at a single injection, and the treatment may be repeated as soon as the fluid has been absorbed, usually a matter of several hours. If absorption is slow, the fluid usually distributes itself throughout the subcutaneous tissues of the entire body and thus constitutes a reservoir which may be drawn upon at need. When sclerema is present, hypodermoclysis is unsatisfactory. Reactions are rare; occasionally there is a transient rise of temperature. The admission of a small amount of air into the subcutaneous tissues, as occasionally happens, should occasion no concern. Hypodermoclysis appears to be less painful to infants than to adults; they frequently fall asleep after the needle is in place.

*Intraperitoneal Injections.*—This route possesses the double advantage over hypodermoclysis that the fluid is more rapidly administered and more rapidly absorbed. The solutions used are those recommended for hypodermoclysis. The apparatus is the same, and the technic of introduction of the needle identical with that previously given for diagnostic puncture of the peritoneum. The presence of distention or peritoneal adhesions are contra-indications; the latter are seldom present in infancy, the age at which this procedure is most useful. Accidents from perforation of the intestine are almost unknown. The introduction of solutions too cold or too hot is apt to be accompanied by symptoms of shock. It has been shown that microscopic evidences of inflammation are present during the first twenty-four hours following such injections. The changes are minimal, consisting in the accumulation of a few leukocytes in the peritoneal cavity. This is not a contra-indication to this form of treatment.

*Intravenous Infusions.*—The ease with which this procedure is accomplished depends very largely on the skill of the operator. With suitably sharp needles, those experienced in intravenous technic can enter the superficial veins of the scalp, neck, elbow, or ankle of even small infants. While the superior longitudinal sinus can easily be entered for the withdrawal of a sample of blood, the administration of fluids by this route is not to be recommended except after other avenues have failed and except when the solutions used are such as not to cause harm if by accident they be injected into the subarachnoid space. Under no circumstances



should arsphenamine, sodium bicarbonate, or calcium chloride solutions be given through the fontanel.

The amount of fluid which can be injected intravenously in a short time is limited, since there is great danger of overloading the circulation. If large amounts of fluid are required, one must proceed very slowly; in infants the rate should not exceed 10 c.c. per minute. Because of the technical difficulties in giving prolonged intravenous infusions in infants, this route is seldom used in the treatment of dehydration. It is employed rather when specific medication is required and smaller quantities of fluid are given, as with concentrated glucose or saline, bicarbonate, calcium, or arsenical preparations. In older children, intravenous infusions are more generally used; the discomfort of subcutaneous treatments is more striking and the difficulties of intravenous therapy are less marked.

**Transfusion.**—In the past ten years a striking increase has occurred in the use of transfusions in pediatrics. They are employed not only in anemic conditions but to combat infections and states of intoxication. As a means of replacing fluid, transfusion is superior to infusions of saline and glucose, since the fluid is retained for a longer time. The amount introduced is comparatively small; it is unwise to inject at one time more than 20 c.c. per kilogram (10 c.c. per pound) of body weight, or approximately one-quarter of the total blood volume; otherwise there is danger of overloading the circulation.

The blood of the recipient must be matched with that of the prospective donor to insure compatibility.<sup>2</sup> In the actual administration of the blood it may be transferred immediately to the patient before time for coagulation has elapsed, or an anticoagulant may be mixed with it. In the former method the blood is drawn into a paraffined syringe by one operator and passed without delay to a second operator who injects it into the recipient's vein, which has already been entered with the needle. This method has the advantage that no foreign substance is added to the blood and that the temperature of the blood is maintained; the disadvantages, that it requires two skilled operators and that the procedure does not usually go off smoothly unless the patient's vein is exposed and cannulated. In the latter method, in which sodium citrate up to a final concentration of about 0.2 per cent is used, the blood may be administered according to the technic for any intravenous infusion, as described above. This method requires less personnel and permits a more leisurely approach to the vein. Reactions following transfusion are somewhat less frequent than in adults, and usually less severe.

Since 1923 the intraperitoneal route has been frequently employed for the transfusion of citrated or, preferably, defibrinated blood, as originally advised by Siperstein and Sansby. Blood so introduced begins to enter the general circulation almost immediately, and is sometimes entirely absorbed within a few hours. The matching of donor's and recipient's blood should be carried out exactly as in the case of intravenous transfusion. We do not believe that this is the method of choice. It may, however, be useful when difficulties are encountered in entering veins. The absorption of blood is not always rapid; we know of instances in which the greater

<sup>2</sup> Classification of Blood Groups:

Landsteiner (International)

Moss

Jansky

O

A

B

AB

4

2

3

1

1

2

3

4



part of the blood administered was still present in the peritoneal cavity at the end of a week.

**Hydrotherapy.**—In general, cool baths are used in the reduction of fever, hot baths as stimulants in collapse.

*Cold Sponging.*—For this purpose water at about 80° to 85° F., or equal parts of alcohol and water, may be employed. The body should be sponged for from ten to twenty minutes, and then wrapped in a blanket without further dressing. Cold sponging must be frequently employed in order to be efficient in reducing high temperature.

*Cold Pack.*—The child should be enveloped in a small sheet wrung from water at a temperature of 100° F. Upon the outside of this, ice may now be rubbed over the entire trunk and repeated in from fifteen to thirty minutes, or cooling may be allowed to take place from evaporation alone. The pack may be continued from a few minutes to several hours, according to circumstances. Additional comfort is afforded by keeping an ice-cap on the patient's head and a hot-water bottle at his feet.

*Cold Bath.*—The child is put into a bath at 100° F., the temperature being gradually lowered by the addition of ice or cold water to 75° or 80° F. The body should be well rubbed while the child is in it. On removal, he should be quickly dried and rolled in a warm blanket. The bath is usually continued from five to ten minutes.

*Hot Bath.*—The patient should be put into the bath at a temperature of 100° F., the water being gradually raised to 103° F. or even to 105° F., but not above this point. The body should be rubbed meanwhile, and cold applied to the head. A thermometer should be kept in the water to see that the temperature does not go too high, for the danger of burning must be kept in mind.

**Mustard Bath and Mustard Pack.**—For the former, mustard is added in the proportion of one teacupful to two or three gallons of water at body temperature, and the bath may be continued until the patient's skin becomes well reddened or until the nurse giving it experiences a tingling in the arms. For the mustard pack, the child should be enveloped for ten or fifteen minutes in a large towel or sheet saturated with mustard water, one tablespoon of mustard to a quart of tepid water.

**Local Application of Cold.**—This is best effected with an ice-cap or ice-collar, though either of them is apt to be strongly resented by young infants. Compresses wrung out of ice water are somewhat less efficient.

**Local Application of Heat.**—The requirements for poultices and hot fomentations in infancy do not differ from those in adults. In the use of these, as well as of hot-water bottles, the precautions against burning the patient must be as rigid as for an unconscious adult. Electric lamps for the local application of radiant heat are available in many designs and have been of service in a number of conditions, particularly where there is local suppuration.

**Applications to the Mouth, Nose and Throat.**—For cleansing lesions in the mouth of infants and for the application of remedies, cotton swabs rolled on tooth-picks are most serviceable. Painting the pharynx is not a very effective procedure and is always strongly resented, and the use of sprays or gargles is usually impossible up to the age of five or six years. Under these conditions, the best means of



access to the pharynx is through the instillation of drops into the nose. Preparations must be used which are not too irritating and which will do no harm if swallowed or inhaled. Paraffin oil introduced in this way has been known to be aspirated into the lungs, setting up a foreign-body reaction about the droplets (lipoid pneumonia).

**Inhalations.**—Inhalations may be given to older children by allowing them to breathe steam from a kettle or special inhaler. For infants and younger children a tent should be used, into which steam is led from a croup kettle. The danger of fire, formerly so great when alcohol burners were used, is minimized by the use of an electric hot plate.

**Oxygen Administration.**—In pneumonia and certain other conditions involving faulty pulmonary ventilation, it is often desired to increase the oxygen concentration of the inspired air. Ideally, this is best effected by placing the patient directly in a specially constructed chamber in which the partial pressure of the atmospheric gases can be accurately controlled, but such chambers are so expensive that but few of them exist. A satisfactory substitute requiring only a moderate complexity of apparatus is the oxygen tent, a canopy of impervious material which can be suspended over the head and shoulders of the patient—in the case of infants, over the entire patient—and in which the air is kept circulating by a motor so that carbon dioxide is removed and oxygen added as required. In an atmosphere of 35 to 40 per cent oxygen many patients experience an immediate and gratifying relief of dyspnea and cyanosis. Higher concentrations of the gas are apt to irritate the lungs.

Over short periods of time, and in emergencies where circumstances do not permit the use of the tent, oxygen can be quite satisfactorily administered through a small catheter introduced 2.5 to 5 centimeters (1 to 2 inches) into the nose and held in place with adhesive tape. A wash bottle inserted between the oxygen tank and the catheter aids in the control of flow of the gas. The valves of most tanks, unless a reducing valve is used, turn stiffly and are apt to release a large volume of gas suddenly; it is therefore wise to regulate the flow before inserting the catheter into the patient's nose.

**Gastric Lavage.**—The introduction of a soft catheter or stomach tube into the infant's stomach appears to cause far less disturbance than in the case of an adult, but beyond infancy it is so upsetting as to be inadvisable except in emergencies such as poisoning. Although little danger exists of the tube's being accidentally introduced into the larynx, since it is seldom possible to pass it anywhere except into the esophagus, it is good policy to pause a few seconds after the tube is in place to make sure there is no to-and-fro motion of respired air. About a pint of warm water is ordinarily used as a washing fluid, being run in and siphoned out in divided doses. When thick mucus is abundant, a 1 per cent solution of sodium bicarbonate is preferable. The tube should be pinched tightly on withdrawal.

In some infant feeding cases, the simple passage of the tube for expulsion of gas is a useful measure.

**Gavage.**—This consists in the introduction of food into the stomach by a tube passed through the mouth or through the nose. After the stomach has been emptied, the food is poured in through a funnel or, if viscous, injected slowly with



a syringe. When this means is depended on for the entire intake of food, the interval between feedings should be not less than four hours.

**Enemata and Intestinal Irrigation.**—Simple enemata of soap or salt solution are useful for the relief of constipation. When an immediate effect is desired the most efficient fluid is one containing glycerin—for an infant, one teaspoonful to one ounce of water. Oil enemata are useful when the fecal mass is hard and dry and expelled with difficulty. Enemata should be given with a soft rubber bulb or through a rubber catheter. The use of 5 per cent glucose solutions by rectum has been mentioned in the section on Administration of Fluids. Other types of nutrient enemata are not practical.

In toxic states, as an antipyretic measure, and for the removal of intestinal gas a more thorough irrigation may be used. The apparatus required consists of a fountain syringe, five or six feet of rubber tubing, and a flexible rectal tube or soft rubber catheter (26 or 27, French scale). At least a gallon of water should be used. Elevation of the hips and gentle kneading of the abdomen should be employed during the irrigation, to facilitate the introduction of the water into the upper part of the colon. As the irrigation of the colon almost invariably excites active peristalsis of the lower ileum, this part of the intestine is emptied as well. There is no danger of overdistention of the intestine if the reservoir is elevated not more than three feet above the patient, for excessive fluid is readily expelled around the tube. Where the object of irrigation is simply to cleanse the intestine, normal salt solution may be used; when fluid administration is desired, tap water is to be preferred. For the relief of distention magnesium sulphate and glycerin solutions, or equal parts of milk and molasses, are useful. The temperature of the solution used may be varied according to the special indications. For ordinary purposes 95° or 100° F. is suitable; when the body temperature is high, or when there is much pain, tenesmus and straining, colder water has advantages.

Occasionally in the relief of intestinal distention the passage of the rectal tube without irrigation is helpful; the tube may be left in position for several hours.

**Serum Treatment.**—The use of antitoxins and antibacterial substances will be dealt with in detail in connection with the diseases with which they are concerned. In general it may be stated that infants and children tolerate foreign sera well and that the per kilogram dose used is often much higher than in the treatment of adults. Although the number and severity of protein reactions is relatively small, owing to the fact that the serum treatment of a disease at this age is apt to represent the patient's first contact with foreign serum protein, the danger of an immediate, unfavorable reaction must be borne in mind, particularly when the patient shows evidence or gives a history of any of the conditions related to allergy—at this age, chiefly eczema and asthma. We believe it to be a good therapeutic principle always to be forewarned of this danger when serum is to be administered by careful inquiry into the past history and by the use of a skin test for sensitization. The administration of serum is discussed in detail elsewhere.

**Anesthetics.**—As a general anesthetic, ether is by far the safest for children. Its only contra-indication is pulmonary disease. Chloroform has a smaller margin of safety; with a struggling child it is easier to give an overdose. The occasional cases of severe chloroform poisoning have done much to discourage its use in this



country. The same may be said of ethyl chloride, often used abroad. Nitrous oxide, while useful in older children for momentary operations and for induction of ether anesthesia, is not well borne by infants unless suitably combined with oxygen. In the hands of experienced anesthetists, ethylene-oxygen mixtures appear to have a fairly wide margin of safety for patients of any age. In the rare cases of sudden death during administration of an anesthetic which are associated with "status lymphaticus," the fault lies in the peculiarities of the patient rather than in the choice of agent.

The administration of general anesthetics by rectum appears likely to find greater favor in the future than has been the case in the past. Ether, organic halides, and substances of the barbitol series have been given in this way. By far the most satisfactory results have been obtained with avertin, the use of which is described in connection with tetanus.

Local anesthetics are on the whole not as helpful in operations on infants and children as in the case of adults. In early infancy, particularly within the first three or four months, it is often possible to perform an abdominal operation such as the Fredet-Rammstedt operation for pyloric stenosis under the combined influence of morphine, sugar pacifiers,<sup>3</sup> and local anesthesia; success in such cases depends in part, however, on the feebleness of the patient. Robust infants and children up to school age or beyond usually require a general anesthetic when any is called for.

**Massage.**—Gentle friction with the bare hands, with starch powder, or with cocoa butter or some other oil, even when performed by one not specially trained, has often a beneficial influence on appetite and the inclination to sleep, in infants as well as in older children, particularly when they are suffering from chronic disease or in convalescence.

## THE USE OF DRUGS

It should be a fundamental principle never to give a medicine without a clear and definite indication, also not to give a nauseous dose when one that is palatable will answer equally well. The simpler the prescriptions are made, the better.

The question of dosage is complicated not only by the occasional occurrence of idiosyncrasies, but also by the fact that certain drugs, such as atropine and salicylates, are particularly well tolerated by young patients, while with others, notably morphine and its derivatives, the dosage should be regulated by the body weight. The following is a useful rule applicable to many cases:

<i>Age</i>	<i>Dosage</i>
3 years .....	$\frac{1}{5}$ adult dose
1 year .....	$\frac{1}{10}$ adult dose
3 months .....	$\frac{1}{20}$ adult dose

**Antipyretics.**—Febrile reactions in children are usually greater than in adults. Thus, conditions which in an adult might produce a rise of temperature to only

<sup>3</sup> One or two teaspoons of cane sugar wrapped in gauze and moistened with water. Sometimes a dozen or more are used at a single operation.



100 or 101° F. are in a child not infrequently accompanied by a temperature of 104° F. or even more. The best guide for the employment of antipyretics is not so much the height of the fever as the presence of nervous disturbances: extreme restlessness, myoclonic twitchings, or convulsions. The physical measures described in the preceding section are more effective than drugs in reducing temperature alone.

Except in cases of malaria, quinine should not be employed to control fever in children. Of the many coal-tar derivatives available, aspirin and sodium salicylate have the advantage of causing little depression. To an infant of one year, 2½ grains (160 milligrams) may be given every hour or two hours until the desired effect is produced. For a child of five years, 5 grains (320 milligrams) may be given in the same manner.

**Sedatives.**—For many of the milder conditions where sedatives are required, barbital derivatives such as luminal are satisfactory. To an infant under six months, ⅛ grain (8 milligrams) may be given; for an infant of one year the dose is ¼ grain (15 milligrams); for a child of five, ½ grain (30 milligrams); in either case, the dose may be repeated in four hours if necessary. Chloral is usually well borne even by small infants. Since it is often irritating to the stomach it may be advantageously given by rectum. The rectal dose for an infant of one month is 1 grain (65 milligrams); three months, 2 grains (130 milligrams); one year, 3 to 5 grains (190 to 320 milligrams). Doses by mouth should be about half as large. They may be repeated every two to four hours, according to indications. As a sedative for use over long periods of time, as in the treatment of chorea in older children, chloretone has certain advantages.

In the use of opiates, relatively smaller doses are required for infants and children than of most drugs. The most useful preparations for young children are paregoric, morphine sulphate, and codeine phosphate. The following table gives what may be considered safe initial doses at the different ages:

TABLE IX  
INITIAL DOSES OF OPIATES FROM ONE MONTH TO FIVE YEARS

Opiates	Age			
	1 Month	3 Months	1 Year	5 Years
Paregoric .....	℥ ii (0.12 c.c.)	℥ iii (0.18 c.c.)	℥ v to x (0.3-0.6 c.c.)	℥ xv to xxx (1-2 c.c.)
Morphine sulphate ...	gr. ¼ <sub>100</sub> (0.6 mg.)	gr. ⅓ <sub>60</sub> (1.0 mg.)	gr. ¼ <sub>40</sub> (1.6 mg.)	gr. ⅓ <sub>20</sub> (3.2 mg.)
Codeine phosphate ...	gr. ½ <sub>25</sub> (2.5 mg.)	gr. ⅓ <sub>15</sub> (4.0 mg.)	gr. ⅓ <sub>10</sub> (6.0 mg.)	gr. ¼ (16 mg.)

Ordinarily, doses like the above should not be repeated within an hour. In the hypodermic use of morphine its effects are always more uniform and striking than when the drug is administered by mouth, and the dose should therefore be smaller.

**Stimulants.**—Alcohol is well tolerated even by young infants; it is, however, in no sense a valuable circulatory stimulant. Other drugs which are used as stimulants are employed in childhood with much the same indications as in later life. The following table indicates the dosage:



TABLE X  
DOSAGE OF STIMULANTS FROM THREE MONTHS TO FIVE YEARS

Stimulants	Age		
	3 Months	1 Year	5 Years
Caffein citrate .....	gr. ¼ (16 mg.)	gr. i (65 mg.)	gr. ii (130 mg.)
Epinephrine (1:1000 solution)	℥ iii (0.2 c.c.)	℥ vi (0.4 c.c.)	℥ x (0.6 c.c.)

Other stimulants have not proved of value.

**Tonics.**—With the growing appreciation on the part of the profession, as well as of the public, for the need of the child for sunlight, fresh air, clean surroundings, and suitable exercise, with the increased knowledge of vitamins and food values, and with due regard for the psychological aspects of disease and convalescence, the use of medicinal tonics is fortunately waning. Preparations once classed as general tonics, like cod liver oil, various combinations of iron, alcohol, arsenic, and so on, are now used in a more specific sense. The bitter tonics play but a small part in psychotherapy.

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## SECTION II

### DISEASES OF THE NEWLY BORN

The diseases of the newly born infant are in many respects peculiar. Many of them result from physiological adjustments accompanying birth or from accidents of labor. A large group is represented by infections to which these infants are either peculiarly susceptible or are particularly subject to exposure. Many congenital malformations are seen only in the newly born, either because their serious nature is incompatible with prolonged life or because they tend to be outgrown. Malformations will be discussed under the systems which they involve.

## CHAPTER V

### ASPHYXIA

The respiration of the child *in utero* is carried on by means of the placenta. Through this organ oxygen is received and carbon dioxide given off. With the interruption of the placental circulation the supply of oxygen is cut off and carbon dioxide accumulates in the blood. It is probably the accumulation of carbon dioxide or the resulting increase in hydrogen ion concentration which supplies the initial stimulus to the respiratory center. The same factor is responsible for the continuance of respiration. Ineffective attempts at respiration may occur *in utero* or during parturition, but as a rule the first attempt takes place only after birth.

The term "asphyxia" is used to describe all cases in which spontaneous respiration is not established with sufficient promptness or sufficient force to maintain life.

**Etiology.**—Asphyxia may be of prenatal origin, or it may result from complications of labor.

**Prenatal Causes.**—These include malformations of the diaphragm, the heart and great vessels, or the brain. Intra-uterine disease of the lungs is a rare cause. The asphyxia often seen in premature infants appears to depend on a lack of development of the function of the respiratory center.

**Causes Associated with Parturition.**—These are far more common. Any factor interfering with the placental circulation may be responsible: a prolonged second stage of labor, maternal convulsions or hemorrhage, the use of pituitrin preventing relaxation of the uterus in the second stage, or death of the mother. The placental circulation may be interfered with by pressure on the cord, winding of the cord about the child's neck, early separation of the placenta, etc. The result of such circulatory obstruction is a cerebral anemia and consequent failure of the respiratory center to function. In rare instances the respiratory center may be stimulated before birth by the increased vascosity of the blood, and aspiration of amniotic



fluid, mucus, blood, meconium, etc., may result. Organic lesions of the nervous system resulting from birth injury, particularly cerebral hemorrhage, commonly result in asphyxia. In certain instances damage to the phrenic nerve in the neck appears to be responsible.

**Pathology.**—In infants dying of asphyxia there are seen the usual changes found in death from suffocation, together with the effects of attempts at breathing *in utero*. There is general congestion of all the viscera, particularly of the brain and its meninges, the liver, and the lungs. They may show small, punctate hemorrhages, and occasionally large extravasations. Blood or bloody serum may be found in any of the serous cavities. The right heart is overdistended with dark, soft clots, and the blood generally is more fluid than normal. The lungs may contain no air, but more frequently there are small, scattered areas in which lobular inflation has taken place. If the child has lived several hours there are larger areas of expanded lung, especially in the upper lobes, and these may even be emphysematous, if artificial inflation has been employed. In the mouth, nose, larynx, trachea, and even as far as the alveoli, there may be found aspirated material—amniotic fluid, vernix, blood, mucus, or meconium. In extra-uterine asphyxia there may be organic changes in the viscera—cerebral hemorrhage, malformations of the brain, the heart and blood vessels or the diaphragm, or, in rare instances, the evidences of intra-uterine pneumonia or pleural effusion.

The chemical studies of Eastman have shown that in severe asphyxia the oxygen content of the cord blood approaches zero; there is a high carbon dioxide tension and a high lactic acid content. The pH is usually in the neighborhood of 7.0.

**Symptoms.**—Under normal conditions the newly born infant begins at once to scream and to use his limbs, the purplish color of the skin giving place in a few moments to a rosy pink. In the first degree of asphyxia—*asphyxia livida*—the child is deeply cyanosed. Either no attempt whatever is made at respiration, or it is superficial and repeated only at long intervals. The pulse is slow, full, and strong. The vessels of the cord are distended. Muscular tone is preserved, and also cutaneous irritability, so that with the application of almost any kind of external stimulus respiration is excited and the symptoms disappear.

In the second degree—*asphyxia pallida*—the picture is quite a different one. The face is pale and death-like, though the lips may still be blue. The heart's action is weak, and by palpation can rarely be felt at all. By auscultation the sounds are feeble, irregular, and usually slow. The cord is soft, pale, and flaccid, and its vessels nearly empty. The sphincters are relaxed and meconium oozes from the anus. There is complete loss of tone in the voluntary muscles, so that the extremities and entire body seem perfectly limp. Cutaneous sensibility is abolished. The extremities are often cold. There may occur a few short, convulsive contractions of the respiratory muscles, but these are without effect and soon cease. Unless such cases receive the most prompt and efficient treatment, the heart's action becomes more and more feeble until it ceases and death occurs. Other infants are partly resuscitated and may survive for a few hours or days, when they gradually sink, respiration becoming more and more feeble in spite of all efforts to maintain it. Between these two extremes all degrees of severity are seen.



**Diagnosis.**—The recognition of asphyxia itself offers no difficulties. The difficulty lies in determining whether the asphyxia is the result of an organic lesion, such as a meningeal hemorrhage. It is often impossible to decide this question at once. A cerebral hemorrhage that is not large enough to cause the death of a child immediately after birth seldom produces characteristic symptoms until thirty-six or forty-eight hours have elapsed. Coma and a bulging fontanel are the earliest signs of hemorrhage; there may be convulsions or evidence of paralysis. A bloody spinal fluid may be found.

**Prognosis.**—This depends upon the grade of asphyxia and the treatment employed. There is but little tendency to spontaneous recovery in any form. In the milder cases recovery is almost invariable with any intelligent treatment. In the severest cases the outcome is always doubtful, although by persistent effort many infants that are apparently hopeless may be saved. In a prognosis as to the ultimate result, the frequent complication of asphyxia with meningeal hemorrhage should always be kept in mind.

**Treatment.**—In every case the first step is to clear the mouth and pharynx of mucus. This may be done by the finger covered with absorbent cotton, but is more satisfactorily accomplished by suction with a catheter and rubber bulb.

External stimulation of the skin—either thermal or mechanical—should then be tried for a few minutes. The alternate use of hot and cold baths is often useful. The hot bath should be between 103° and 106° F., the temperature always tested with a thermometer. After a few moments the child should be momentarily plunged in cold water or the body may be doused with it. Pinching or gentle spanking may also be employed. The above means will suffice in the great majority of cases. In severe forms, however, they are inadequate. If there is no response to the foregoing methods of stimulation within a few minutes, the child should be wrapped in a warm blanket and artificial inflation of the lungs should be undertaken. Mechanical manipulations for inducing artificial respiration have now been largely displaced by intratracheal and intrapharyngeal insufflation. Intratracheal intubation requires experience and can be conveniently employed only in cases so severe that the pharyngeal and laryngeal reflexes are abolished. When intrapharyngeal insufflation is used the precaution should always be taken of passing an additional catheter into the stomach to permit the escape of gas and prevent distention of that organ. An effective gas mixture for insufflation that has been widely used during the last decade is oxygen containing 7 per cent carbon dioxide, first suggested by Yandell Henderson. This was designed to accomplish the double purpose of supplying oxygen to the child and stimulating the respiratory center with carbon dioxide. The observations of Eastman would seem to indicate that such a concentration of carbon dioxide is superfluous, for it supplies a pressure of this gas no greater than is already present in the fetal blood. Oxygen alone gives quite as satisfactory results. Its pressure during administration should be controlled by a manometer, and the flow interrupted periodically.

When oxygen is not available insufflation can be accomplished by means of expired air. The direct mouth to mouth method should not be employed, but with a catheter and a wash bottle between the operator and the child this method is quite satisfactory.



As long as the heart's action continues attempts at resuscitation should not be abandoned. In the event of cardiac failure, epinephrine may be injected intracardially.

The after-treatment of asphyxia is equally important. It is not enough to start spontaneous respiration or to make the child cry, since resuscitation is often only partial and relapses are likely to occur. For the first twelve hours the child should be stimulated every fifteen minutes by slapping until he cries well. All severe cases should be carefully watched for the first twenty-four or thirty-six hours since a repetition of the treatment is often necessary.

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## CHAPTER VI

### CONGENITAL ATELECTASIS

This condition is one in which there is a persistence of the fetal state in the whole or in any part of the lung. The lung of the fetus is of a uniform dark red color and shows lobular divisions very distinctly upon its surface. It is firm and solid and sinks readily in water. Connective tissue is abundant and forms distinct fibrous septa which stretch through the lungs in every direction.

The first parts to be inflated are the anterior borders of the lungs, then the upper lobes, and finally the lower lobes posteriorly. The superficial lobules are nearly always expanded before those in the interior of the lung. The inflation is sometimes irregular because of mucus in some of the bronchi. Under normal conditions expansion takes place readily and is usually complete in two or three days.

**Etiology.**—Expansion of the lungs depends upon the establishment of a regular respiration and one of adequate depth. Hence, atelectasis is a constant accompaniment of asphyxia. It may clear up entirely when normal respiration is established, or it may do so only in part, so that a portion of the lung remains in the fetal condition. The causes of congenital atelectasis are, therefore, in the main, the same as those of asphyxia. There are other cases, however, in which there is no history of early asphyxia, where the primary respirations, although taking place spontaneously, have not been of sufficient force and depth to produce full pulmonary expansion. This usually occurs in feeble infants or in those who are premature. In other instances great abdominal distention, either from gas or fluid, may impede respiratory movements and thus prevent the normal expansion of the lungs.

**Pathology.**—In cases where the child dies during the first few days the amount of expanded lung is often small, frequently not more than one-fourth of the pulmonary area. The expanded portion is usually the anterior borders of the upper lobes. This is often the seat of acute emphysema. The rest of the lung is still in the fetal state; it is of a brownish-red color, very vascular, does not crepitate, and shows the lobular outlines both on the surface and on section. With a little force the atelectatic lung may be completely inflated.

If children have lived a longer time, nearly the whole of the upper lobes and the anterior portion of the lower lobes are usually well inflated. These portions are either normal or slightly emphysematous. The posterior portions of the upper lobes and the lower lobes are almost invariably the seat of the atelectasis. On the surface even these portions may present quite a large area of expanded vesicles, but the underlying portion may be solid to the touch, and may crepitate but slightly. On section it is seen that only the most superficial part of the lung is inflated, while the interior of the lobe is unexpanded. Small hemorrhages are frequently seen beneath the pleura.



It is usual for both lungs to be affected, and often, but by no means uniformly, to about the same degree. It is frequently a great surprise to discover that a child has lived for some weeks without presenting any signs of cyanosis, although using not more than one-third of his pulmonary area. This variety of atelectasis closely resembles the hypostatic pneumonia of delicate infants, and very often the two conditions are associated. It may require the microscope to decide between them. If congenital atelectasis has existed for a considerable time, there are usually found evidences of pneumonia. Inflation is not so easy as in recent cases, but with force the greater part of the lung can usually be expanded. The right auricle and ventricle are commonly distended with dark clots, and there is occasionally found some congenital abnormality. The liver and spleen and other abdominal organs usually show marked congestion.

**Symptoms.**—Atelectasis may occur in infants of normal weight who appear vigorous, but this is distinctly exceptional. As a rule, the infants who suffer from it are small and delicate; they gain poorly in weight. Their circulation is poor, they have cold extremities and may have a subnormal temperature. The cry is never loud and lusty; some of them will not cry at all.

In one group of cases the children are asphyxiated at birth, and attempts at resuscitation have been only partially successful. Although the patients may live for several days, there is cyanosis which gradually deepens, and death takes place from asphyxia, exhaustion or convulsions.

In other infants who may or may not have been asphyxiated at birth there develop attacks of cyanosis in which respiration may be shallow and irregular. Death may occur in such attacks—being often preceded by convulsions. On several occasions we have seen cases in which there was nothing whatever to attract attention to the lungs until the final attack of cyanosis occurred.<sup>1</sup>

**Diagnosis.**—The physical signs are of much less value than the symptoms. It should be remembered that the principal seat of the disease is the lower lobes posteriorly. Percussion usually gives relatively good resonance over the entire chest, although this may be somewhat diminished posteriorly. There is not, however, so much change as one would expect to find, for the collapsed areas are surrounded by others which are overdistended, and there are in the midst of the collapsed parts, especially upon the surface, lobules which are inflated. If the two sides are involved to about the same degree, as is often the case, no difference in the percussion note over the two lungs may be detected, and the change from the normal may be so slight as not to be appreciable. Where only one lung is affected a difference can usually be made out. The respiratory murmur is rarely bronchial, but generally only feeble in its intensity, and rather ruder in quality than normal. The cardiac sounds may be transmitted with abnormal intensity.

<sup>1</sup> Two cases from the New York Infant Asylum illustrate this point: The infants were twins, ten weeks old and delicate. Suddenly at night one child was taken with convulsions, became deeply cyanosed, and died in two and a half hours. He had been suffering from a slight attack of indigestion for a week previous. The other twin had been apparently well on the previous day. Two hours after the death of the first child the second was taken with similar symptoms, dying in a few hours. At autopsy there was found very extensive atelectasis involving the posterior part of the upper and the greater part of both lower lobes. The lesions were almost identical in the two cases. In both, the stomach was greatly distended with food and gas. We have repeatedly seen the effect of overdistention of the stomach in producing cyanosis in young children, and in this instance we believe it to have been the exciting cause of the final symptoms. It was subsequently learned that during the six weeks of observation the nurse had witnessed several slight attacks of cyanosis in one of the infants.



As in the case of percussion, in unilateral cases, auscultation is of some value in diagnosis; but the changes are seldom sufficiently marked to be readily recognized when both sides are involved. Fine dry râles are frequently heard at the end of inspiration especially if this be deep.

Little assistance is given by the roentgen ray in the majority of cases. Irregular shadows, particularly at the bases, may be found, but there is nothing characteristic. When the process is unilateral, however, the picture may be very striking—the irregular areas of consolidation on one side and a lack of density, due to compensatory emphysema, on the opposite side.

Congenital atelectasis may be readily confused with hypostatic pneumonia, with which, as already pointed out, it often coexists. There may be great difficulty in deciding whether the attacks of cyanosis are due to congenital heart disease. The presence of a heart murmur is inconclusive, for many circulatory anomalies give no murmurs, and on the other hand loud accidental murmurs may occur at this age. The characteristics of accidental murmurs are discussed elsewhere.

**Prognosis.**—It must not be assumed that all cases of congenital atelectasis terminate fatally. A large number doubtless recover, in whom the condition was not recognized. Others who have shown marked symptoms may with appropriate treatment, or even without it, gradually recover. The longer the condition persists the more difficult expansion of the lungs becomes. When symptoms persist beyond two or three weeks without amelioration the prognosis is usually unfavorable.

**Treatment.**—In the newly born child, whether asphyxiated or not, the physician should see to it that the infant cries loudly. Unless this cry is repeated several times daily, cutaneous stimulation should be resorted to, as in cases of asphyxia. Expansion of the lungs is much more easily induced during the first few days of life, becoming more and more difficult the longer it is delayed. Provided the condition is recognized, treatment is fairly successful. In institutions where delicate infants spend most of the time in their cribs, atelectasis is likely to be found. An infant needs exercise, and this is often only to be obtained by taking the child from his crib several times a day, by general friction, massage, the stimulus of fresh air, etc. Nothing is more certain to perpetuate atelectasis than to allow the infant a life of feeble vegetative existence. In feeding such children especial care should be taken to avoid abdominal distention. Attacks of cyanosis should be treated in the same way as asphyxia of the newly born.



## CHAPTER VII

### PHYSIOLOGICAL JAUNDICE

Jaundice is seen in the newly born from a variety of causes—malformations of the bile ducts, congenital syphilis, or acute pyogenic infections associated with hepatitis. All these conditions are quite distinct from the common form of physiological icterus (*icterus neonatorum*; idiopathic icterus) which alone will be discussed here.

**Etiology.**—Few subjects have given rise to wider speculation than this form of jaundice. Among the many etiological possibilities that have been suggested only two appear to play an important part: (1) increased blood destruction, resulting in the formation of an unusually large amount of bile pigment, and (2) a limited capacity on the part of the liver cells to excrete bile pigment at this period of life.

The peculiarities of the fetal circulation require a higher red blood cell count and more hemoglobin than is needed after birth. This increased demand is met by blood formation in the liver and spleen. The readjustment begins during the last month of fetal life with obliteration of the blood islands in the liver. During the first ten days after birth a further (and probably more rapid) readjustment in this direction takes place—the islands of blood formation in the spleen disappear, and an excessive destruction of red blood cells takes place, with the result that there is a rapid fall in the circulating red blood cells and hemoglobin. A considerable fraction of the total stock of hemoglobin in this way becomes superfluous and is converted, mainly in the bone marrow, into bilirubin as the first step in its elimination. An excessive amount of bile pigment is thus thrust upon the liver cells for excretion. The liver at this period has been shown to have an impaired excretory function, at least as far as dyes are concerned. The result is that not all of the bilirubin formed is excreted in the bile. Much of it accumulates in the blood stream, giving rise to clinical jaundice. This increased bilirubin in the serum was first demonstrated by Ylppö. Even at birth the child's blood contains three or four times as much pigment as the maternal blood. There is a rapid rise after birth, and in a few days the pigment may reach twenty times the normal value. This high bilirubin content diminishes at first rapidly, then slowly; the normal is not reached for several weeks. All infants show this increased amount of bile pigment. Those who later develop icterus have a higher bilirubin content at birth and subsequently. Icterus is noticeable when the blood serum contains more than 1.25 milligrams per 100 c.c.

Although bilirubin may be found in the urine in considerable amounts, it is often absent even when the jaundice is conspicuous. When present it may be in the form of crystals, rather than in solution. These facts suggest that the kidney of the newly born child is unable to excrete bilirubin as well as subsequently—



a factor which may play an accessory part in maintaining the high serum bilirubin.

With the establishment of a normal rate of blood destruction and the increase in functional activity of the liver, the pigment is removed. The difference between the icteric and the nonicteric infant is one of degree only. It is quite proper in such circumstances that the condition should be spoken of as "physiological icterus."

**Incidence.**—In 900 consecutive births at the Sloane Hospital for Women, jaundice was noted in 300 cases; in 88 it was severe, in 212 it was mild. According to statistics from various lying-in hospitals in Germany it was found in 40 to 80 per cent of all infants. In the 300 cases just referred to jaundice was noted on the first day in 4, on the second day in 19, on the third day in 72, on the fourth day in 94, on the fifth day in 67, and on or after the sixth day in 44. From the second to the fifth day is therefore the usual period for its appearance. It occurs with equal frequency in both sexes.

It usually increases in severity for one or two days and then slowly disappears. The average duration in the mild cases is three or four days but it is not uncommon for it to last a week or ten days. Severe cases are occasionally seen in which it may last for two months or even longer. Physiological jaundice is regularly found in premature infants, in whom it is likely to be severe and prolonged. The reason for this is discussed elsewhere.

**Symptoms.**—The icterus may be detected first of all in the sclerae. As the process advances it can be seen in the skin of the face and chest; only when the jaundice is severe does it become noticeable in the extremities. In the pigmented races jaundice is more readily appreciated in the mucous membranes than in the skin.

In jaundiced infants who have died from accident or other causes the skin, subcutaneous tissue, and most of the internal organs have been found icteric. There is staining of the internal coat of the arteries, the endocardium, the pericardium and the pericardial fluid. The liver is usually slightly discolored, the bile ducts are normal. The spleen and kidneys are involved only in severe cases. With the exception of the basal ganglia, which may be deeply bile-stained, the tissues of the brain and cord and the cerebrospinal fluid are free from pigment. Small hemorrhages may be found in various parts of the body, particularly on the serous surfaces.

**Diagnosis.**—The diagnosis of physiological jaundice is to be made from other causes of icterus which are found at this age—that associated with sepsis, with congenital malformation of the bile ducts or with cirrhosis of the liver, which is usually syphilitic. In early sepsis it is doubtful if the infection produces the icterus; it is more likely that the two conditions are associated. In later sepsis jaundice may be due to an hepatic lesion, usually multiple abscesses. The icterus seen with sepsis is usually mild.

The diagnosis of the ordinary mild physiological icterus offers no difficulties. The time of appearance and short duration are quite characteristic. The stools are bile-stained, for the impairment of liver function is usually slight. The Van den Bergh reaction is indirect, indicating that increased hemolysis is of greater importance than hepatic insufficiency.



When physiological jaundice is unusually severe and prolonged, diagnosis becomes increasingly difficult. In such cases the hepatic function is likely to be very greatly impaired, and it seems to be this factor which is responsible for the intensity and the duration of the icterus. The stools seldom contain more than traces of bile pigment; there may be none at all. The Van den Bergh reaction may be found diphasic, but after the first week or two it is only the direct reaction which is obtained. The findings are thus identical with those of an obstructive hepatitis due to bile duct malformations or syphilis. Syphilis will usually present other manifestations during the early weeks of life—either clinical, radiographic or serological. From a congenital malformation, however, the diagnosis can be made only by waiting or by exploratory laparotomy. The longer the duration, the greater is the probability that a malformation is present. The severe case of physiological icterus usually begins to improve at the end of two months. If there is no improvement at the end of two or three months, one may safely assume that a malformation is present. An exploratory operation should then be performed. The presence of bile in the stool does not rule out a malformation. We have seen a case with traces of bile regularly present in the stools, in which a complete obstruction of the ducts was found at autopsy. The pigment must have reached the intestine through the circulation. Physiological jaundice requires no treatment.

A rare form of severe icterus—*icterus gravis*—is seen affecting successively several members of a family. The condition usually terminates fatally within a few days, death occurring with convulsions. It may last for weeks, however, and instances of recovery are reported. Just how this condition can be differentiated from severe physiological icterus is not clear. The pathological findings have furnished no adequate explanation for the cause of death. Transfusion appears to benefit some patients.

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## CHAPTER VIII

### HEMORRHAGES

Hemorrhages are frequently seen during the first days of life. They may be traumatic or spontaneous.

#### TRAUMATIC OR ACCIDENTAL HEMORRHAGES

These may result from injury received before birth or from misguided efforts at resuscitation. The large majority of them, however, occur during labor. They are due either to pressure in natural labor or to means employed in artificial delivery. Abnormally large infants or small premature ones are more likely to suffer. In the former group labor is more likely to be difficult; in the latter group lack of protection or increased fragility of the blood vessels seems to be responsible.

**Hematoma of the Sternomastoid.**—Hemorrhage into the sternomastoid muscle leads to the formation of a tumor in the belly of the muscle. It is a rather rare condition. It occurs most frequently after breech presentations and is somewhat more common on the right side than on the left. Occasionally it is bilateral.

The hemorrhage is confined within the muscle sheath. It results from twisting of the head rather than from the employment of undue force in delivery. The muscle fibers are ruptured to some extent. The tumor is due partly to extravasation of blood and partly to inflammatory products, for a certain amount of reaction is usually present.

The tumor is usually noticed in the second or third week of life. It varies from  $\frac{3}{4}$  to  $1\frac{1}{2}$  inch in length, being oval in shape. It is movable beneath the skin, almost cartilaginous to the touch, and sometimes slightly tender. The situation is usually about the center of the muscle. There is no discoloration of the skin. The head is usually slightly inclined toward the affected side and rotated toward the opposite side. Passive rotation toward the affected side is impeded.

The condition requires no treatment. The swelling slowly diminishes in size, and in most cases by the end of the third month it has nearly or quite disappeared. Occasionally a slight torticollis remains for a longer time, but it is rare for permanent deformity to result.

**Cephalhematoma.**—This is a subperiosteal tumor containing blood occurring over the bones of the skull, usually the parietal bone.

*Etiology.*—In most cases there is no evidence of external injury. Besides the conditions predisposing to all hemorrhages, there is the increased pressure in the blood vessels of the head during delivery, especially when labor is prolonged or difficult; there may be changes in the bone, such as an imperfect development of the external table; and, finally, there may be changes in the blood itself. Cephalhematoma is a rather rare condition; it was present, according to the statistics of the Sloane Hospital for Women, in 20 of 1300 consecutive births, or 1.6 per



cent. The condition is more common after first or difficult labors, and in vertex presentations; occurring twice as often in males as in females, probably from the greater size of the head.

*Pathology.*—In the 20 Sloane cases, the situation was over the right parietal bone in 12; over the left in 2; over both parietals in 4; over the occipital in 2. The location of the tumor seems to have a very close relation to the position of the head in the pelvis. In 8 of the right-sided cases the head was in the left occipito-anterior position. Of the cases with occipital tumors, both were breech presentations. Of the 16 cases with a single tumor the labor was natural in 10, tedious in 4, and in 2 forceps were used. Of the 4 double cases, 2 were forceps deliveries.

In rare cases triple tumors are met with, one over each parietal and one over the occipital bone (Fig. 9). The attachment of the periosteum along the sutures



FIG. 9.—TRIPLE CEPHALHEMATOMA IN INFANT SEVEN DAYS OLD.

usually limits the tumor to the surface of one bone. It never extends across the sutures or over the fontanel. In cases where there is a more definite injury, the tumor may be present over any one of the cranial bones, but more frequently over the parietal. The seat of the hemorrhage is beneath the periosteum. The scalp shows punctate hemorrhages and sometimes infiltration with blood. In recent cases the blood is fluid; later it is coagulated. The amount of extravasated blood is usually from half an ounce to an ounce. The cases following natural delivery are generally uncomplicated. The traumatic cases may be complicated by extravasations between the bone and the dura (internal cephalhematoma), or by meningeal or cerebral hemorrhages. If there is a wound, infection may be followed by purulent meningitis and even by cerebral abscess.

*Symptoms.*—The tumor is usually noticed from the first to the fourth day after birth, appearing as a slight prominence in one of the positions mentioned. Gradu-



ally increasing in size, it attains its maximum at the end of a few days, and then slowly diminishes. In size and shape the usual tumor may be compared to the bowl of a tablespoon. In marked cases it may be one-third the size of the child's head. To the touch it is soft, elastic, fluctuating, and irreducible. It does not increase with the cry or cough. There are no signs of inflammation. Usually the tumor does not pulsate, although in rare instances pulsating cephalhematomata have been seen. Very soon the tumor is surrounded by a marginal ridge. At first this is from coagulation of blood, but later it may be bony. The prominent ridge with the soft center gives a sensation somewhat like that of a depressed fracture. Sometimes on pressure there is obtained a sort of parchment-crackling. This is generally found as the swelling is subsiding, and is usually due to the formation of minute bony plates upon the inner surface of the periosteum. It may be found when there is nothing but thin coagula to explain it. In certain cases following severe traumatism, cephalhematoma may be complicated with wounds of the scalp, fracture of the skull, and even lacerations of the dura mater or the brain. In such cases the tumor may become inflamed. Abscess may develop, which may open externally or burrow. Fortunately this termination is seldom seen.

As a rule, without any interference the uncomplicated cases go on to recovery. The disappearance of the tumor may be expected in from two to four months, depending on its size; but a hard, uneven elevation may remain at its site for a much longer time. The cases due to severe traumatism are more serious, the gravity depending not upon the cephalhematoma but upon the complicating lesions.

*Diagnosis.*—Cephalhematoma may be confounded with encephalocele; this, however, occurs along the line of the sutures, or at the fontanel, is partially reducible, pressure causes cerebral symptoms, and frequently the tumor increases with respiratory movements. Caput succedaneum often appears in the same place as cephalhematoma and at the same time, but this is an edematous, not a fluctuating tumor, and begins to subside by the second or third day. From a depressed fracture of the skull, it is differentiated by the fact that in cephalhematoma there is a tumor and not a depression; the prominent margin which is raised above the contour of the skull is not osseous and the skull can be felt at the bottom of the center of the tumor.

*Treatment.*—The treatment in the uncomplicated cases is simply protective, all such cases tending to spontaneous recovery. No local or general treatment to promote absorption is required. The child should be so placed and so handled that no injury may be done to the affected part. Compresses are unnecessary. If complications exist, such as injury to the bones, dura, or brain, they are to be treated in accordance with general surgical principles. Operative interference is called for only when suppuration has occurred, or when there are brain symptoms which point to the existence of internal as well as external cephalhematoma.

**Visceral Hemorrhages.**—By far the most important of these are the intracranial hemorrhages, which are discussed with diseases of the nervous system. Other visceral hemorrhages are more common in breech deliveries. Extensive hemorrhages may rarely be found in the lungs, but the abdominal viscera suffer more than those of the thorax because less protected against pressure. Small hemorrhages are not uncommon upon the surface of any of the viscera covered



by peritoneum. Larger hemorrhages may result when the trauma at birth or during resuscitation has been considerable. They are most frequently found in the liver and in the suprarenals. Rupture of these organs may cause fatal hemorrhage.

Except for the intracranial variety, visceral hemorrhages give few symptoms and are seldom diagnosed. Pulmonary hemorrhage may give signs of consolidation or hemoptysis. Abdominal hemorrhages may give rise to distention, or there may be sudden collapse and death with rupture of a subperitoneal hemorrhage into the general peritoneal cavity. Rarely it is possible, on the basis of sudden collapse not otherwise explained, to make a correct inference with regard to suprarenal hemorrhage. *Waterhouse-Friedrichsen Syndrome.*

### SPONTANEOUS HEMORRHAGES

**Hemorrhagic Disease of the Newly Born.**—A tendency to bleed is seen with many diseases in the first few days of life, particularly congenital syphilis and pyogenic infections. Infants with severe jaundice show a predisposition to bleed. There is, however, a group of cases in which the hemorrhages are not associated with any other known process. They appear spontaneously and the hemorrhagic tendency disappears after a limited time. The hemorrhages are likely to be extensive; bleeding may occur from the umbilicus, the skin, mucous membranes or any of the internal organs, including the brain. The response to treatment is often striking.

*Etiology.*—The condition is relatively uncommon, occurring in from 0.1 to 1 per cent of all births. It is found in both sexes with almost equal frequency.

Very little is known as to the pathogenesis of the condition. It is not a manifestation of hemophilia and shows neither the sex incidence nor the familial tendency of the latter disease; moreover, hemophilia seldom gives rise to symptoms until the end of the first year. It resembles hemophilia, however, in contrast to other hemorrhagic diseases, in that the clotting time of the blood may be markedly delayed. In 5 cases at the Harriet Lane Home in which the clotting time was studied it was found to be:  $3\frac{1}{2}$  minutes, 8 minutes, 35 minutes and 90 minutes; in one instance the blood failed to clot in 12 hours. The bleeding time was usually, but not invariably, prolonged. Studies of the clotting elements that have been made have not given consistent results. Prothrombin has been found deficient in some instances.

Lucas and others have reported a prolonged coagulation time in many infants showing no hemorrhagic manifestations, which suggests that hemorrhagic disease, like icterus of the newly born, is merely an exaggeration of a normal physiological process. The inference has been made that this hemorrhagic tendency bears some relation to the excessive blood destruction taking place at this period; this finds some support in the observations of Schick, who has shown that in many animals reduction of the high fetal blood count is accomplished by means of placental hemorrhages.

*Pathology.*—Aside from the hemorrhages and anemia of the tissues the autopsy shows nothing. Most of the hemorrhages are small and diffuse, but there is usually one large one which is responsible for the fatal termination. The superficial hemorrhages, although not primarily traumatic in origin, are likely to occur over points of pressure. Any of the mucous membranes or serous surfaces may be the



seat of ecchymoses or of more extensive bleeding. Although large fatal hemorrhages may occur externally, these are more frequently visceral. Large hemorrhages may be found in the gastro-intestinal tract, in the peritoneum or in the meninges; less frequently in the pleural or pericardial cavities.

Ulcers of the stomach or duodenum may be found in a small number of the cases with gastro-intestinal bleeding. This condition is discussed elsewhere; it is doubtless different in etiology from true hemorrhagic disease of the newly born, but may be clinically indistinguishable from it.

*Symptoms.*—The onset is usually during the first week of life, often on the second or third day. A late onset, after the first week, should suggest syphilis or sepsis as a cause of the hemorrhages.

The duration is seldom longer than three or four days. The promptness with which the condition disappears may be striking. In one case under our observation with severe umbilical bleeding and the most extensive subcutaneous hemorrhages we have ever seen, all tendency to bleed had ceased before separation of the cord. It is not uncommon for circumcision to be performed within a few days after the cessation of the hemorrhages without any unusual bleeding. Once improvement begins, it continues rapidly; relapses are unknown.

The hemorrhages are usually multiple. The most common sites of bleeding are the umbilicus, the gastro-intestinal tract, and the skin and subcutaneous tissue. Hemorrhages of the eyes, ears, nose, mouth and genitals are less common. Those of the meninges, cephalhematoma, and the internal serous cavities are comparatively rare.

The bleeding usually begins gradually. There is continuous oozing rather than a sudden gush of blood. With increasing loss of blood there follows prostration and loss of weight. Diarrhea is not infrequent. The temperature may be high, low or subnormal. Many of the symptoms depend on the situation of the hemorrhage.

**INTRACRANIAL HEMORRHAGES.**—These are considered elsewhere under Diseases of the Nervous System.

**UMBILICAL HEMORRHAGE.**—A slight oozing from the umbilicus not infrequently occurs when the ligature has been improperly applied. This is generally controlled by simple measures. Spontaneous hemorrhage is quite different. It occurs rather later than bleeding from the mucous membranes, usually occurring between the fourth and the seventh day. There may be bleeding into the cord as well as from its free extremity. A slight stain upon the dressing is usually the first note of warning, but in exceptional circumstances a gush of blood is the first symptom. The hemorrhage may be temporarily arrested by various means, but it shows a strong tendency to recur in spite of everything which is done. The usual duration is two or three days. It has been known, however, to persist for twelve or fourteen days, and it may be fatal in less than twenty-four hours from the time it is noticed.

**HEMORRHAGE FROM THE STOMACH AND INTESTINES.**—Bleeding occurs much less frequently from the stomach than from the intestines. The latter is called *melena*. Gastro-enteric hemorrhages begin, in the great majority of cases, during the first three days of life. The blood vomited is usually in dark-brown masses, and not very abundant; more rarely it is bright red. The quantity varies from one dram to half an ounce. Vomiting is likely to be excited by nursing. The blood discharged from the bowels is always dark colored, usually intimately mixed with



the stool, very rarely in clots. If in doubt between blood and meconium, one should make a chemical test for hemoglobin. Concealed hemorrhage into the stomach may take place, which may even be sufficient to produce death, no blood being vomited or passed by the bowels.

**HEMORRHAGE FROM THE MOUTH AND NOSE.**—The quantity of blood is rarely large; but it is here that it is often first seen. Its source may be the mucous membrane of the mouth, pharynx, esophagus, stomach, or bronchi. It may be associated with ulceration of the hard palate, with thrush, or with fissures of the lips.

Hemorrhages from the nose are infrequent, and are more often due to syphilis than to other causes. These are rarely profuse, but are frequently repeated.

**SUBCUTANEOUS HEMORRHAGES.**—These often appear in places exposed to pressure, such as the sacrum, heels, occiput, or back, but may occur anywhere. In some cases these hemorrhages are very extensive, as in one under personal observation, where nearly one-third of the thorax was covered. When subcutaneous hemorrhages occur alone or form the principal lesion, the prognosis is favorable.

**HEMATURIA.**—The urine is not only stained with blood, but sometimes contains clots. The hemorrhage may have its origin in the bladder, urethra, or kidney. Blood coming from the kidney is sometimes due to the irritation of uric acid infarctions, and may have nothing to do with the general hemorrhagic disease.

**HEMORRHAGE FROM THE CONJUNCTIVA.**—The blood usually comes in drops from between the eyelids, chiefly from the tarsal surface. It is generally preceded by conjunctivitis.

**HEMORRHAGE FROM THE FEMALE GENITALS.**—This not infrequently occurs without hemorrhages elsewhere, and under such circumstances is rarely serious. Cullingsworth collected 32 cases in children under six weeks of age—no case having resulted fatally. These are not to be regarded as cases of precocious menstruation.

*Diagnosis.*—Any abnormal bleeding occurring during the first week of life should be looked on as a manifestation of hemorrhagic disease of the newly born. Prolongation of the coagulation time and delayed retraction of the clot confirm the diagnosis, but in the presence of spontaneous or uncontrollable bleeding one is scarcely justified in withholding therapy until these criteria have been applied. The abrupt cessation of bleeding in response to treatment is of itself important in establishing the diagnosis.

The recognition of external hemorrhage offers no difficulties; internal hemorrhages, on the other hand, are easily overlooked. Spurious hemorrhages from the stomach may occur, blood being vomited which has been swallowed during birth or nursing. The source of bleeding may also be the mouth, nose, or pharynx. Syphilis should be suspected when the bleeding is chiefly nasal.

*Prognosis.*—Before the introduction of treatment with human blood the prognosis was very bad; of 709 cases collected by Townsend, the mortality was 79 per cent. Now, with proper treatment most cases recover. No case should be looked upon as hopeless, for recovery has repeatedly taken place after transfusion when the infant was moribund.

*Treatment.*—Transfusion is a specific remedy and in virtually all cases effects immediate and lasting cessation of bleeding; it rarely requires repetition. In most



instances the blood of either parent may be used, since at this age the iso-agglutinin titer in the infant's blood is not high enough to cause incompatibility; the amount required is not large—5 to 8 c.c. per pound of the infant's body weight is ample.

Successful results have been obtained with intraperitoneal infusion of citrated blood; on account of its technical simplicity, this method often proves useful. Intramuscular injection of whole blood—10 c.c. into each buttock is the usual dose—has the advantage that it may be given at once with no more elaborate equipment than a syringe and needle, and that it does not require a preliminary test of compatibility of the donor's and recipient's bloods; it is, however, less swift and less sure in its action. After intramuscular injection the site should be massaged to promote absorption. Subcutaneous injection has little to recommend it. Sidbury has reported successful transfusion given into the umbilical vein.

It has been demonstrated that the effective component of adult blood is contained in the serum or plasma, but no advantage is derived from preliminary separation of the corpuscles and, indeed, much valuable time may be lost. The use of horse serum, once popular, should be discouraged. The local treatment of bleeding points in the skin or mucous membranes is almost entirely unsuccessful in severe cases and must not be permitted to divert time and attention away from the essential general treatment described.

When there has been considerable loss of blood, the resulting anemia may require separate treatment. Transfusion generally kills both birds with one stone—arrests the bleeding and relieves the anemia. There may be residua from internal hemorrhage, particularly in the central nervous system, for which no treatment is available.

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## CHAPTER IX

### THE ACUTE INFECTIONS OF THE NEWLY BORN

Infection of the newly born infant may occur *in utero* when the mother is suffering from almost any of the common infectious diseases. Thus, children may be born with smallpox, typhoid fever, measles, malaria, pertussis, pneumonia, etc., or they may develop these diseases shortly after birth.

Unless prenatal infection has occurred the newly born infant possesses a natural immunity to many of the specific diseases which may last for months. To other diseases his susceptibility is unusually great, and among these may be numbered infections produced by the common pyogenic organisms.

#### ACUTE PYOGENIC INFECTIONS

**Sepsis of the Newly Born.**—A variety of pathological and clinical conditions are grouped together under this heading. In some of them the process is confined to local inflammations which may terminate in suppuration; in others the process becomes generalized and pyemia or septicemia may result. Infections of this class were formerly very common, especially in the large lying-in hospitals, but with the general adoption of aseptic obstetrics their frequency has greatly diminished.

*Etiology.*—In rare cases the source of infection may be the vaginal secretion of the mother or the mother's milk. The infection may enter through any of the accessible mucous membranes, mouth, nose, ears, conjunctivae or genitalia, or through any wound or abrasion of the skin. By far the most common portal of entry is the umbilicus. Infection results from the neglect of aseptic precautions; it may occur during delivery; it may occur before or after the separation of the cord.

The organisms most frequently concerned are the common pyogenic bacteria—staphylococci, pneumococci and streptococci; organisms of the colon group are not rare. The gonococcus may be found, particularly in cases accompanied by joint suppuration. *B. pyocyaneus* or other organisms are occasionally responsible.

*Pathology.*—The umbilicus is involved in the large majority of cases. The inflammatory process may be localized and involve only the abdominal wall in the immediate neighborhood. It may terminate in resolution, abscess or gangrene, abscess being the most frequent. Such abscesses may be superficial or may burrow in the abdominal wall.

Frequently, however, the inflammation extends along the umbilical vessels producing septic thrombosis and suppuration. Saccular dilatations filled with pus may be found at several points. The vessels may be involved for only a short distance or throughout their entire length. In the latter case there may result peritonitis, or septic processes anywhere in the body. Extension along the umbilical vein leads primarily to suppurative hepatitis. The more virulent infections spread



rapidly along the umbilical vessels and become generalized, often leaving no external evidence of infection about the umbilicus.

With generalized infections there may occur inflammations and suppurative processes in any part of the body. There may be involvement of any of the serous membranes—peritonitis, meningitis, empyema, pericarditis or endocarditis. There may be pneumonia. Suppuration of the bones or joints is common. Multiple abscesses may occur in any part of the body—either superficial or in the internal organs. The buccal mucous membranes or the alimentary canal may be involved in catarrhal inflammations. Erysipelas is exceedingly common. It may spread directly from the umbilicus or from any superficial abrasion or inflammatory lesion. The septic processes in the newly born show one characteristic difference from those of later life, namely, the great variety of lesions which may be encountered in the same individual. Although any of the above mentioned pathological processes may occur independently, it is not uncommon to find pneumonia with empyema, pericarditis, meningitis and peritonitis, all in the same case.

The frequency of different visceral lesions in 87 autopsies reported by Bednar was as follows: peritonitis in 29, pneumonia in 15, empyema in 10, meningitis in 9, meningeal hemorrhage in 8, encephalitis in 7, enterocolitis in 5, pericarditis in 4. In 31 cases there was umbilical arteritis, and in 9, umbilical phlebitis. Runge's later observations showed more frequent involvement of the umbilical vessels; of 36 cases, 30 showed umbilical arteritis, 3 showed umbilical phlebitis, and in only 3 was the umbilicus normal.

*Symptoms.*—These may begin at any time during the first two weeks of life—rarely before the third or after the fifteenth day. The general symptoms are exceedingly irregular. Fever may be high but it is frequently normal or even subnormal; its course may vary greatly. Wasting is constant and rapid; it occurs even in the absence of intestinal complications. Not infrequently wasting is the only symptom. Icterus is commonly present. In cases with involvement of the liver it may be severe. Hemorrhages are common in sepsis and may be the direct cause of death. They may come from the umbilicus, the intestine, or any of the mucous surfaces. There may be a general hemorrhagic skin eruption. Nervous symptoms occur even in the absence of cerebral complications; there may be restlessness, a whining cry, irregular respirations and even convulsions. Diarrhea is frequently present; vomiting is less common.

The local symptoms may be very obvious. The umbilicus may show evidences of inflammation; pus may exude from it on pressure. Suppurative arthritis is not uncommon. The symptoms of the various visceral inflammations may be pronounced but they are often obscure or absent altogether. It is not uncommon to find at autopsy, meningitis, peritonitis, or pneumonia, which were entirely unsuspected during life.

The clinical varieties of these septic infections of the newly born vary as widely as the pathological findings, and are no doubt dependent upon the type of invading organism. The most virulent infections are likely to be caused by hemolytic streptococci, but this is not invariably the case. Bacilli of the colon group are likely to produce subacute infections.

A rare form of sepsis occurring epidemically was described by Winckel, in



which there are cyanosis, icterus and hemoglobinuria. The symptoms are fulminating in character, usually terminating fatally within two days. There is high fever and rapidly developing asthenia. The most striking features are the peculiar color (*maladie bronzée*), due to the intense icterus and cyanosis, and the urine which is smoky and contains hemoglobin in considerable quantity, albumin, casts and occasionally red blood cells, but no bile pigment. There are postmortem parenchymatous changes in the viscera and hemorrhages. It is not known what bacteria are responsible for this form of sepsis.

Buhl described a form of fatty degeneration of the newly born as a separate disease. The lesions consisted of inflammatory changes in the viscera with fatty degeneration. The clinical features, as described, resemble those of pyogenic infection, and since the observations were made before modern methods of bacteriological study were available, it is altogether probable that Buhl's disease is merely a form of pyogenic infection of the newly born.

In the absence of local evidences of disease at the umbilicus or elsewhere, sepsis of the newly born can only be suspected. The constitutional symptoms may be very indefinite. Fever and leukocytosis at this age are most variable. A blood culture will usually settle the question.

The course of these infections is most irregular. The prognosis is almost invariably bad when erysipelas or any important visceral inflammation is present. The resistance of these patients is so feeble that the tendency of every inflammation is to spread. Only patients with localized inflammations, such as those of the joints, skin, etc., are likely to get well.

*Prophylaxis.*—Pyogenic infection of the child, like puerperal fever of the mother, may be considered a preventable disease. In olden days 5 to 10 per cent of all infants born in institutions succumbed to it. In modern institutions, however, it has been almost completely abolished. Among 2300 successive labors at the Sloane Hospital for Women (New York), covering about eight years, not a single marked case occurred. From these figures it would appear that the occurrence of serious pyogenic infection is the fault of the physician or nurse in attendance.

The umbilicus should be treated like any other open wound; none but sterile dressings should be applied to it. Careful attention should also be given to any superficial abrasions of the skin or mucocutaneous surfaces. Finally, every septic case occurring in an institution should be immediately isolated. A nurse in charge of a mother with sepsis should not have the care of her infant.

*Treatment.*—This is largely symptomatic. Local suppurations should be treated surgically. Something can be accomplished by careful attention to the general nutrition. Drugs and stimulants are of little avail. The intravenous use of dyes in treating sepsis has proved disappointing. While transfusion may be of benefit in older children not much is to be expected from it at this age.

### OPHTHALMIA

A mild catarrhal conjunctivitis is often seen in newly born infants. It may be due to a variety of organisms which may have been present in the vaginal canal of the mother. It may result from antiseptics which have been applied to the eyes after birth. Such inflammations are usually benign; the eyes should be



washed with boric acid two or three times a day, but no further treatment is required. The term *ophthalmia neonatorum* is usually applied to that more serious group of infections due to the gonococcus.

**Gonococcus Ophthalmia.**—In the majority of cases infection occurs during labor from the vaginal secretions of the mother. It may occur after birth, however, when the infant has been handled by an infected person, usually the mother, or from cloths or other materials which may come in contact with the eyes.

**Symptoms.**—When the infection has occurred at birth symptoms usually appear on the third day. They are often fulminating from the outset. There is marked swelling of the lids, chemosis, and copious purulent discharge. There may be hemorrhages from the lids. Ulceration and perforation of the cornea may follow, with permanent loss of vision. It is a mistake to assume that all cases of gonococcus ophthalmia are so virulent from the start. The onset may be insidious. For several days there may be what is apparently only a mild catarrhal conjunctivitis, and the process may gradually increase in severity and lead eventually to destruction of the eye. The disease is occasionally complicated by other symptoms of gonococcus infection of a pyogenic nature. Many cases of acute polyarthritis have been observed.

**Diagnosis.**—There is seldom any difficulty in diagnosis when the ocular symptoms are severe. The cases which escape detection are those with an insidious onset. Too much faith is often placed in the efficacy of prophylactic treatments, the possibilities of postnatal infection being overlooked. The physician should not neglect to make a bacteriological smear in all cases of conjunctivitis, no matter how benign they may appear.

**Prophylaxis.**—Prophylaxis is of the utmost importance. Nothing has yet been found which is more effective than the original Credé method: the instillation of one or two drops of 2 per cent silver nitrate into the eyes immediately after birth. Instead of the silver nitrate, 10 per cent argyrol or 1 per cent mercurochrome may be used. In 1874, before the introduction of the Credé treatment, between 10 and 15 per cent of children born in institutions developed gonococcus ophthalmia. Its routine use has reduced the incidence to from 0.1 to 0.2 per cent. Even at the present time, however, in states where this treatment is not obligatory about 40 per cent of the inmates of institutions for the blind are the victims of this disease. The statistics are rapidly improving where prophylaxis has been made compulsory.

**Treatment.**—Every case of gonococcus ophthalmia should be isolated with the strictest precautions. Everything which comes in contact with the patient should be carefully disinfected or destroyed. If only one eye is involved the sound one should be protected by covering it with a compress kept wet with an antiseptic solution. In the treatment of the affected eye, greater emphasis is to be put on careful and frequent irrigations than on disinfectants. In severe cases, such irrigations must be carried out every half hour or every hour, day and night. An eye dropper with a bulbous tip should be used, inserted alternately at the inner and outer angle of the eye, and the fluid injected with sufficient force to empty the conjunctival sac. Either a half saturated solution of boric acid or saline may be used in this way. At the beginning of the treatment two or three drops of 1 per



cent silver nitrate should be dropped in the eye. The nitrate should not be repeated unless ulceration of the cornea takes place when the edges of the ulcer may be touched with the solution. Every two hours, 10 per cent argyrol, or 40 per cent protargol, or 1 per cent mercurochrome should be instilled into the eye after thorough irrigation. Treatment should be continued until no gonococci can be demonstrated in smears. Thereafter the irrigations may gradually be eliminated. Next in importance to these measures is the use of cold. It may be applied as ice compresses which are changed every minute or two from a block of ice to the eye. These may be continued one-fourth of the time in the milder cases; in the severe ones almost constantly. When the cornea is involved the pupil should be dilated by atropine.

### OTHER INFECTIONS OF THE NEWLY BORN

The newly born infant seems peculiarly susceptible to *impetigo contagiosa*, epidemics of which are frequently seen in lying-in hospitals. Owing to the greater tendency of the disease to form bullous lesions, the term *pemphigus neonatorum* is often applied. Cases of *dermatitis exfoliativa* may be encountered in such epidemics; they appear to have an identical etiology.

*Tetanus* of the newly born as a result of umbilical infection is now seen very infrequently. It is encountered only when entirely unsanitary measures prevail in districts where tetanus is endemic.

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## CHAPTER X

### MISCELLANEOUS AFFECTIONS OF THE NEWLY BORN

**Lactation of Newly Born.**—A certain amount of hyperplasia of the breasts, with secretion of milk, is so common in the newly born as to be considered physiological. It is most pronounced during the second week, but may continue as late as the third month. Premature infants and those with marked jaundice are said not to exhibit this phenomenon; it is seen with equal frequency in both sexes. The lactating infant's breast is histologically similar to that of the adult (Sinéty) and the secretion, which is popularly known as *witch's milk*, has essentially the composition of colostrum; the quantity varies from a few drops to 15 or 20 cc. The secretion itself is of no importance, and if left alone it usually ceases after a week or two.

Lactation of the newly born has been attributed to a hormone received from the mother through the placenta, but the specific pituitary hormone held to be responsible for lactation—*prolactin*—has not as yet been demonstrated in the infant. The hormone responsible for the Aschheim-Zondek reaction is, however, present in the urine of infants during the first four days of life.

**Mastitis.**—It sometimes happens that the lactation of the infant's breasts prompts the mother or nurse to rub or squeeze them. Such manipulation occasionally leads to serious results by exciting a mastitis; this is rarely seen unless the breasts have been handled. Evidences of inflammation usually begin in the second week. The process may terminate in resolution or suppuration. Occasionally there may develop a diffuse phlegmonous inflammation or erysipelas and the case terminates fatally. In the female it is possible for the cicatrization which follows such an inflammation to interfere with the subsequent development of the gland. Even in the milder cases constitutional symptoms are present—fretfulness, disinclination to nurse and loss of weight.

Mastitis may be prevented by avoiding manipulation of the breasts. When lactation is profuse they may be protected by a cotton pad. If inflammation develops it should be treated along general surgical principles.

**Anuria.**—Anuria in the newly born infant may be due to some malformation of the genito-urinary tract, but more often it has no such significance and represents merely a delay in the onset of renal secretion; the bladder is found by palpation and catheterization to be quite empty. It is not uncommon for the first urine to appear from twelve to thirty-six hours after birth; sometimes it is delayed even longer. The first urine passed is likely to be highly acid and may contain an abundance of uric acid or other crystals.

Suspension of urinary secretion for the first twenty-four hours need cause no anxiety in infants who are in other respects normal.



**Uric Acid Infarctions.**—This term has been applied to deposits of uric acid and urates which are found in the straight tubules and pelvis of the kidney during the first few days of life. Usually both kidneys are affected and all the pyramids of each kidney. In the pyramids the infarctions appear to the naked eye as fine, brownish-yellow, fan-shaped striae. Often there are granular deposits in the pelvis of the kidney. At times evidences of a catarrhal inflammation of the pelvis will be found, including even the presence of blood.

This condition is frequently present during the first ten days of life. It was formerly supposed that the discovery of uric acid infarctions was proof that an infant had breathed, and a certain medicolegal importance was attached to them. This is now known not to be the case, for they are found in stillborn infants.

During the first three to five days of life, as Kingsbury and Sédgwick showed, the blood of the newly born infant contains a relatively high concentration of uric acid, which is apparently derived from the nucleoprotein of blood cells undergoing rapid destruction at this time. The urinary output of uric acid is simultaneously elevated. From the glomerular urine as it passes the convoluted tubules water is reabsorbed to a degree which causes the relatively insoluble uric acid to crystallize out. As the urinary secretion becomes more abundant the deposits are washed out or redissolved in the urine. The scanty urination of the first few days of life has been attributed to these deposits, but it is more likely that this is the cause rather than the result of their occurrence. Evidences of pain on urination and priapism occasionally are present during the early days of life; these have been ascribed to the presence of uric acid infarctions. Rarely the deposits remain in the kidney or in the bladder for a long time and may form the nuclei of calculi. The treatment is to give water freely until urinary secretion is fully established.

**Dehydration Fever.**—Under this heading are included cases receiving too little fluid, with an elevation of temperature which falls promptly when fluid is supplied in proper amounts.

The newly born infant commences to lose water from the body as soon as respiration is established, and continues its loss not only by this route but also through perspiration and intestinal and urinary excretion. Unless the breast milk secretion is supplemented in some way during the first few days, the output of water far exceeds the intake.

Evaporation of water from the skin is the normal mechanism for reducing the body temperature. When there is a deficiency of water this mechanism breaks down and the temperature rises.

Dehydration fever (inanutition fever) is not confined to the first days of life, although it is most commonly seen at that time. It may also occur in older children whose fluid intake is inadequate, or whose fluid loss is excessive.

So far as our knowledge goes, the first to call attention to this condition was McLane, of New York, who in 1890 reported an extraordinary case of hyperpyrexia in a newly born child. Subsequent observations have established the fact that a rise of temperature to 102° or even 104° F. is quite common during the first few days of life when nothing but the breast is given. In two New York institutions where no supplementary fluid was given as a routine, dehydration fever was



observed in 10 to 15 per cent of all newly born infants. It was seen in vigorous infants as well as delicate ones. The fever is accompanied by no evidences of local disease.

*Symptoms.*—The symptoms of this condition are quite uniform and characteristic. The skin is hot and dry with a tendency to become inelastic. The lips are dry. There is marked restlessness and a disposition to suck anything within reach. When the condition is far advanced, the concentration of the plasma proteins rises. The temperature in the most severe cases may go as high as  $106^{\circ}$  F. With such there is usually considerable prostration and a weakened pulse. The fontanel may be sunken. Loss of weight may be rapid and is always greater than the normal loss which occurs at this age. The weight may drop a pound or even two pounds below the birth weight. The rapidity with which the symptoms disappear when water is freely given is very striking. The temperature usually falls to normal within a few hours and does not rise again. When there has been considerable loss of weight, however, the effect of this may last for weeks.<sup>1</sup>

*Diagnosis.*—It is important that this fever should be recognized. The rise of temperature may be the first indication of a condition which, if left to itself, may prove fatal. The temperature of every infant should be taken regularly during the first week. All the usual local causes of fever should be excluded by physical examination. It is hardly possible to confuse this fever with that due to pyogenic infection, which rarely begins before the fifth or sixth day.

*Prophylaxis.*—The prophylaxis of dehydration fever in the newly born should be part of the routine postnatal care; its occurrence can usually be prevented by offering water by mouth between nursings. Many infants will take water well up to the time when the breast milk supply is well established, when they will refuse it; by that time supplementary water is no longer necessary. When water is regularly offered in this way, the incidence of dehydration fever is usually

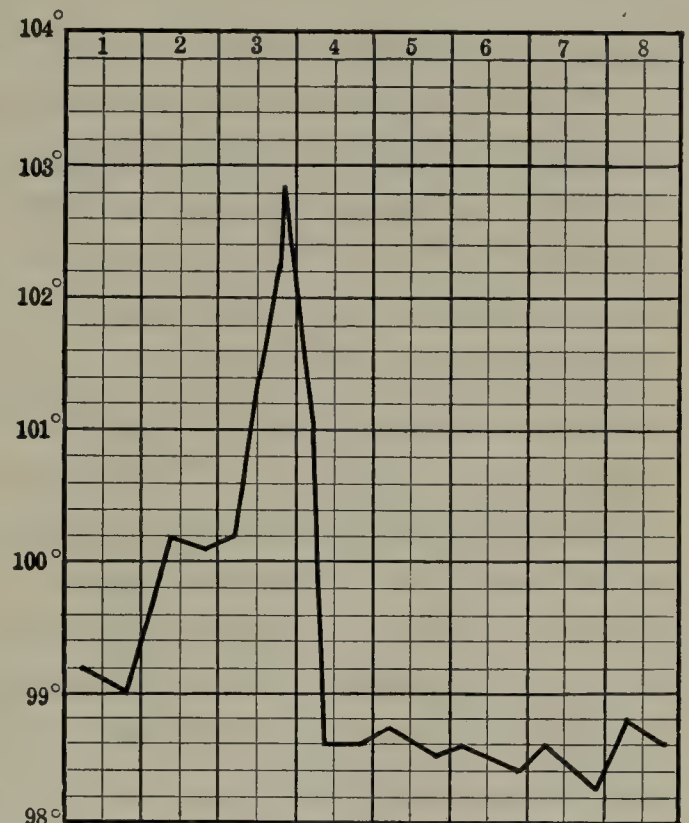


FIG. 10.—TEMPERATURE CHART: DEHYDRATION FEVER.

<sup>1</sup> The following case of dehydration fever is fairly typical of the more severe form: The patient was the second child, the first having died at the age of ten days, from no disease, it was said, but simply from exhaustion. At birth the infant, a boy, weighed  $8\frac{1}{4}$  pounds and was apparently vigorous. During the first forty-eight hours his loss in weight was  $5\frac{1}{2}$  ounces and his condition good. He was seen on the evening of the third day. In the preceding twenty-four hours he had lost 8 ounces in weight, and the temperature had gradually risen, until at the time of our visit it was  $102.8^{\circ}$  F. The body was limp, the child making no resistance to examination. He cried with a feeble whine; the restlessness of the early part of the day having given place to complete apathy. The lips and skin were very dry, the fontanel sunken, the pulse weak. As the father, a physician, expressed it, "he had been wilting through the day like a flower in the sun." Although put to the breast regularly, the child had apparently obtained very little. It was, in fact, impossible to express any milk from the mother's breast. Water was freely given and a wet-nurse secured in a few hours. The first milk was taken from the wet-nurse at 11 p.m., and the temperature, which fell gradually during the night, was normal the next morning and did not rise again. (See chart, Fig. 10.) During the succeeding four days the child gained 18 ounces in weight, and at the end of a week was as well as an average infant of his age.



limited to those infants who exhibit a certain amount of somnolence in the first few days of life.

*Treatment.*—The treatment is simple. Water should be given by mouth, every two hours whenever the temperature rises above 101° F. Gavage may be used with drowsy infants. Parenteral fluids will rarely be necessary. When it is apparent that no appreciable amount of milk is being obtained from the breast by the third day, supplementary feeding should be instituted.

**Birth Injuries.**—As already pointed out, damage to the vascular system frequently occurs at birth or subsequently. The effects of hemorrhage are not confined to loss of blood, but often result in permanent damage to other tissues, particularly the central nervous system. The early and late effects of cerebral hemorrhage are discussed under the Diseases of the Nervous System. Hemorrhage producing injury of the spinal cord is but rarely seen.

The nervous system may, however, be directly injured at the time of birth. Depressed fractures of the skull and fractures of the spine may produce lacerations, and in breech deliveries traction on the lower extremities may cause injury to the spinal cord, amounting sometimes to physiological transection, even in the absence of actual fracture of vertebrae. More common than these are injuries to the brachial plexus, leading to the characteristic Erb's palsy, and injury to the facial nerve, causing Bell's palsy. These conditions will be discussed elsewhere.

The bones and joints may be damaged at birth. In order of frequency, the bones most frequently fractured at birth are the clavicle, humerus, femur and skull. In nearly all these cases there is a history of operative or forcible delivery; breech presentations or version and extraction in the breech position are the most frequent accompanying obstetrical conditions. Head injuries are generally the result of the use of forceps.

*Fractures of the clavicle* usually occur near the center of the bone. There may be no functional impairment and the condition be noticed only as a result of the callus formation which is felt by the mother. In other instances the arm may hang limp. The condition usually requires but little treatment; the sleeve on the injured side may be pinned to the mattress to keep the arm in abduction and external rotation.

*Fractures of the humerus* usually occur just below the deltoid insertion; the shaft is fractured transversely. There is marked deformity; the arm hangs limp, for the radial nerve is usually injured. These fractures rarely give rise to any permanent difficulty, no matter how treated.

*Fractures of the femur* are usually transverse or oblique just above the center of the shaft. This is the most serious of the common fractures of the newly born, for unless properly treated a permanent anteroposterior angulation may result. Truesdell describes a box splint which he has found satisfactory in these cases.

*Fractures of the cranial vault* are decidedly rare. There is usually a fissure fracture without displacement, although depressed fractures have been described. The diagnosis can seldom be made without a roentgenogram, but according to Truesdell it can be suspected from the peculiar character of the cephalematoma. Unlike the ordinary cephalematoma that associated with fracture is present at birth, is irregular in outline and does not extend completely to the margins of



the affected bone; its consistence is soft and watery rather than firm and elastic. With the exception of depressed fractures, these injuries of the skull require no treatment. In the presence of an actual depression of some portion of the skull, operative elevation of the indented fragment may be advisable; it must be admitted, however, that we have seen a number of such fractures treated conservatively with no sequelae of any kind.

The most commonly recognized dislocations are: (1) that of the lower epiphysis of the humerus, (2) that of the upper epiphysis of the humerus, and (3) dislocation of the lower femoral epiphysis. Only the first of these is sufficiently frequent to merit a description. The injury usually occurs during breech extraction; difficulty is encountered in bringing down the arms, and when this is done forcibly a "snap" occurs. There is limitation of motion of the forearm, and crepitus is obtained when the elbow is flexed at a right angle. Since this epiphysis is not calcified and casts no x-ray shadow at this age, the displacement cannot be demonstrated by this means, but after the twelfth day a new subperiosteal calcification beneath the detached periosteum may be visible roentgenographically. The injury tends to right itself.

After breech extraction, when the operator has inserted a finger into the infant's mouth to facilitate flexion of the head, a condition resembling unilateral dislocation of the jaw may persist for a few days, with deviation of the mandible toward the sound side and some interference with sucking. In one patient who came to autopsy while this condition persisted, no actual lesion of the temporomandibular joint was discernible, and it seems likely that this condition is an expression of undue stretching of the ligaments rather than of rupture of the joint capsule.

**Malformations.**—The presence of malformations involving external organs is usually obvious enough. Malformations of the internal organs, however, may give rise to obscure symptoms, which may come on directly after birth or somewhat later. The commonest of those which give symptoms in the newly born infant are the congenital obstructions of the esophagus and intestines, the malformations of the bile passages, and those of the heart and great vessels. A variety of malformations of the larynx and pharynx may give rise to the symptom complex known as "congenital stridor."

These various malformations will be discussed under the systems which they involve.

**Edema of the Newly Born.**—Edema may be present at birth. There is a severe form of generalized edema—*hydrops neonatorum*—which is often associated with extreme erythroblastosis and enlargement of the spleen. Many of these patients do not survive, but in those who do the edema disappears.

Edema of the newly born may appear shortly after birth in infants who are progressing unfavorably, usually in those with extensive atelectasis. It seems likely that circulatory insufficiency plays a part here. Most of these cases do not survive.

Transient edema about the genitals may occur in newly born infants of either sex. It may be present at birth or it may appear during the early weeks of life. Its significance is unknown.



Persistent forms of edema may be present at birth. These are discussed elsewhere.

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## SECTION III

### NUTRITION

Nutrition in its broadest sense is the most important branch of pediatrics. A knowledge of its fundamental principles is essential to the physician if he is to apply preventive and corrective measures intelligently.

## CHAPTER XI

### NUTRITIONAL REQUIREMENTS

**Energy Metabolism.**—Like the adult, the child must be provided with energy (1) for his maintenance (basal) requirements, (2) for his bodily activity, and (3) for the inevitable loss in the excreta. The child differs from the adult in requiring in addition (4) energy for growth. The energy value of foods is usually expressed in calories, which in nutrition work refers to large calories. The different foodstuffs when burned in the body have different energy values, thus:

- 1 gram of fat yields 9 calories
- 1 gram of protein yields 4 calories
- 1 gram of carbohydrate yields 4 calories

Information in regard to the caloric requirements has been obtained by observations in the calorimeter, chiefly by Benedict and Talbot.

*Basal Metabolism.*—The requirements for maintenance are fairly constant in children of the same weight. During the first year of life the daily requirement averages 55 calories per kilogram (25 calories per pound). After the first year the basal requirement tends to become gradually less, approaching the adult value (25 to 30 calories per kilogram).

*Growth Requirements.*—These are somewhat variable since growth is not a constant process. During the early months of life when growth is most rapid there may be required as much as 40 to 45 calories per kilogram (20 calories per pound). At the end of the first year the average is about 15 calories per kilogram (7 calories per pound). This requirement changes little during childhood; there is an increase at the time of puberty, followed by a diminution as the rate of growth declines. Malnutrition may be followed by periods of very rapid growth; at such times it may be necessary to increase the food allowance for growth beyond that just described.

*Requirements for Activity.*—The great variation seen in the food requirements of children results chiefly from differences in their muscular activity. This is true even of very young infants, in whom vigorous crying may increase metabolism by more than 40 per cent. An average allowance for activity during the first year



is 15 calories per kilogram (7 calories per pound). Phlegmatic infants may require only half this amount, while extremely active ones may need four times as much.

*Energy Lost in the Excreta.*—On a mixed diet approximately 10 per cent of the intake is normally lost in the excreta. The loss in nursing infants is slightly

TABLE XI

	Infant 8 Weeks Old, Calories		Infant 10 Months Old, Calories	
	Per Kilogram	Per Pound	Per Kilogram	Per Pound
Basal requirement .....	55	25	55	25
Growth .....	40	18	20	9
Activity .....	15	7	15	7
Loss in excreta.....	10	4	10	4
TOTAL .....	120	54	100	45

less. In diarrhea and other conditions of disturbed digestion the loss may be greatly increased.

**Total Caloric Requirements.**—Average figures for infants eight weeks old and ten months old are given in Table XI.

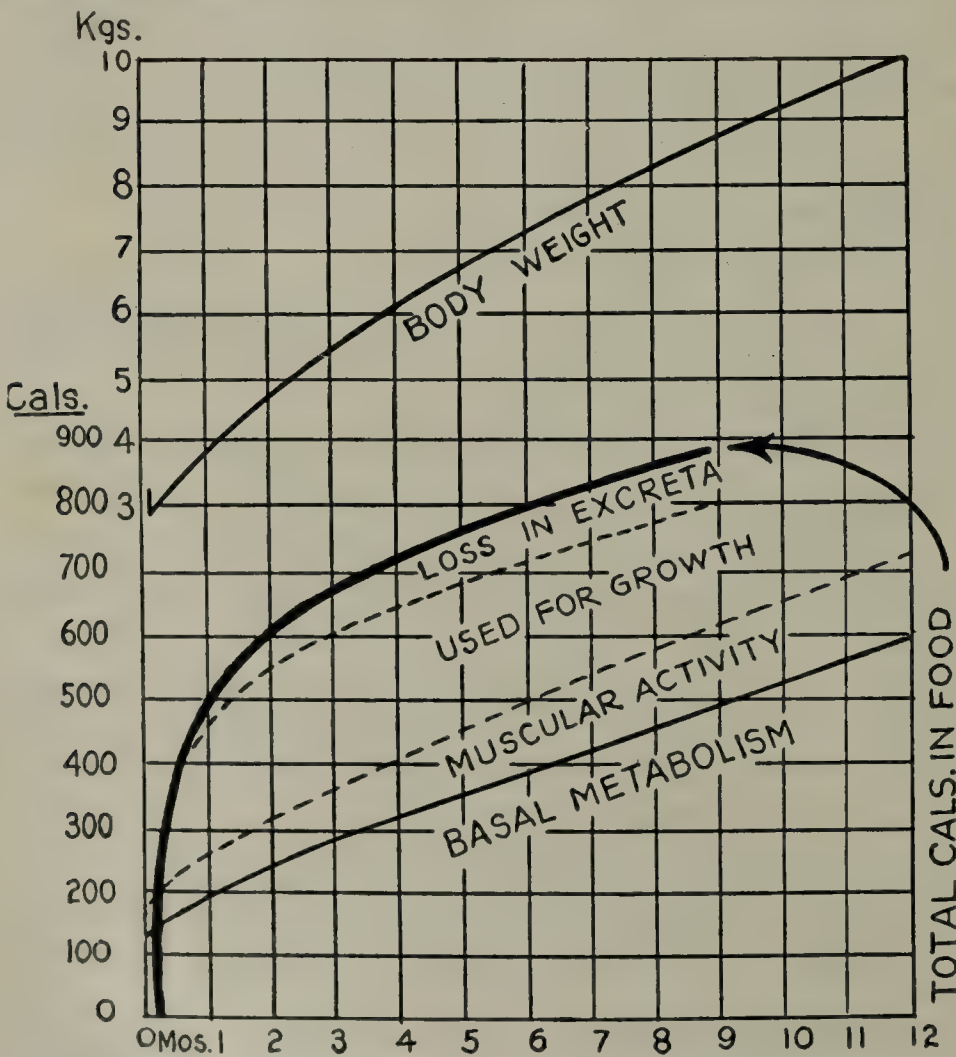


FIG. 11.—METABOLIC REQUIREMENTS DURING THE FIRST YEAR OF LIFE.

(From Talbot, *Am. J. Dis. Child.* 1919, 18: 229.)

The accompanying chart gives the energy requirements for average children during the first year.

During the first week of life the caloric requirements are low, being as a rule about 60 per kilogram. During the second and third weeks they rise rapidly to about 100. They reach the maximum, 120 per kilogram, at about six weeks, and then slowly fall. At the end of the first year they are 100 per kilogram (45 per pound) or 950 calories for an average infant of 21 pounds' weight.

The energy requirements during childhood are given in Figure 12. There is a gradual decrease to approximately 80 per kilogram at six years. This level is maintained until about

sixteen years in boys and thirteen or fourteen years in girls, after which there is a gradual decline to the adult level of 40 or 45 calories per kilogram.



The above data relating caloric requirements to body weight apply only to the *average* child. An obese child is more protected by his subcutaneous fat from loss of heat; his caloric requirements are therefore lower than his weight would indicate. Conversely, a malnourished child needs more calories; it has already

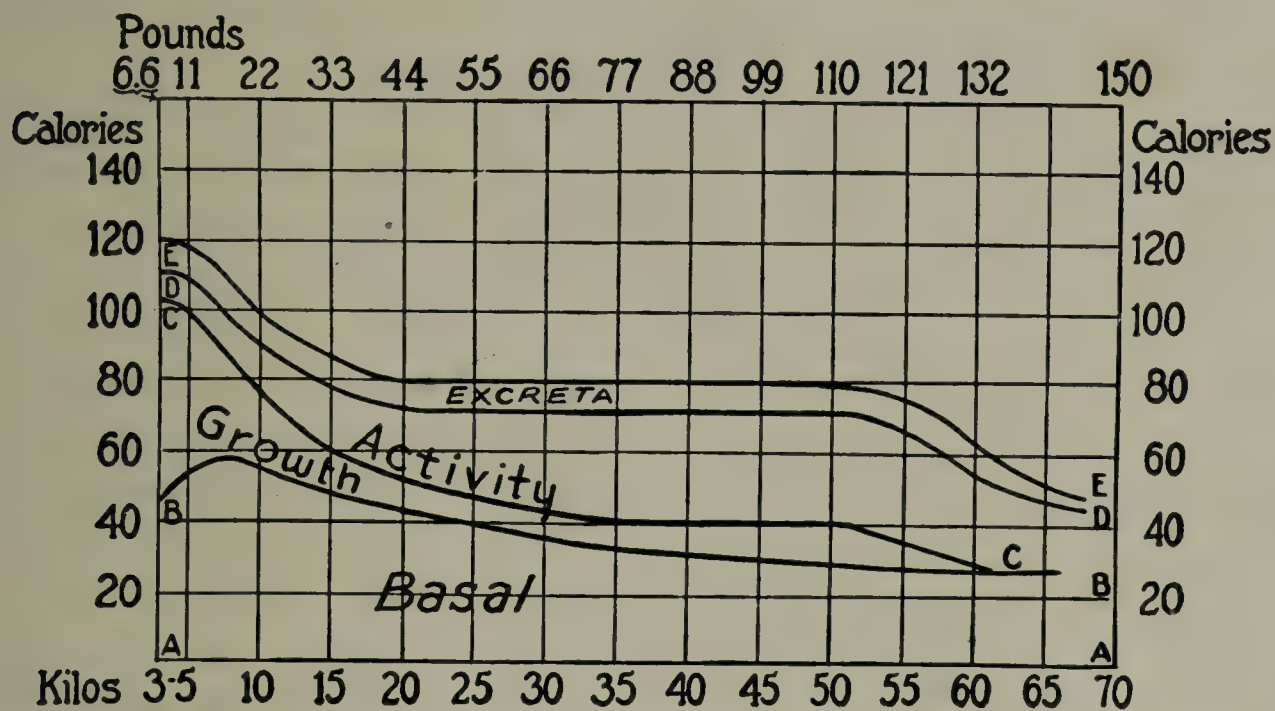


FIG. 12.—CALORIC REQUIREMENTS PER KILOGRAM THROUGHOUT CHILDHOOD

The abscissae indicate weights. The interval between the base line A-A and the curve B-B shows allowance for basal metabolism; between B-B and C-C, that for growth; between C-C and D-D, that for muscular activity; between D-D and E-E, food values lost in excreta. The ordinates under curve E-E show the average total caloric requirement per kilogram at various body weights.

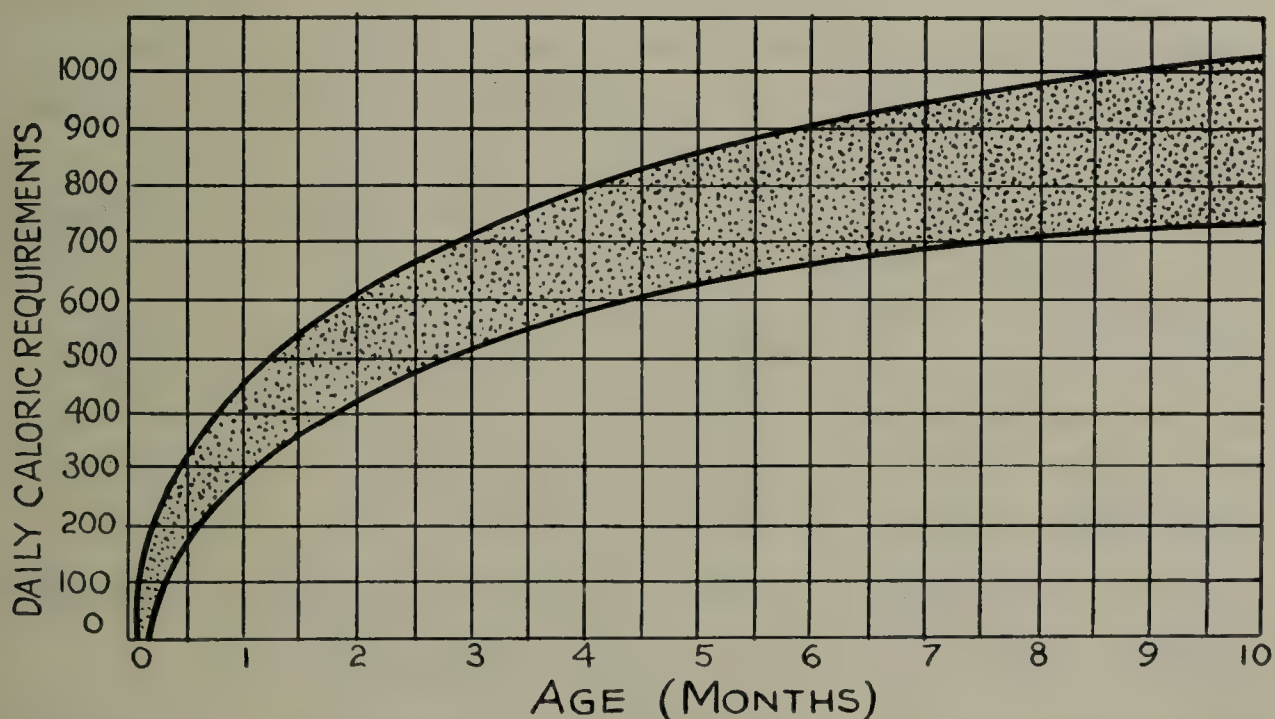


FIG. 13.—TOTAL CALORIC REQUIREMENTS OF INFANTS, SHOWING NORMAL VARIATIONS.

been pointed out that such children may need in addition excessive food for growth. For these reasons it is more accurate to estimate caloric requirements in relation to expected weight<sup>1</sup> (in other words to age) rather than to actual

<sup>1</sup> The calorimetric observations of Wilson, Levine and their collaborators have shown that undernourished infants require more than their actual weight would indicate, and somewhat less than their expected weight would indicate. The expected weight, however, gives a fairly close approximation.



weight. In Figure 13 are given caloric requirements during the first year of life (the width of the stippled zone represents the variations that may be expected due to differences in activity). Figures 14 and 15 give average daily requirements for both sexes from the first to the twentieth year. It will be noted that the food allowance during the period of adolescence is greater for both sexes than

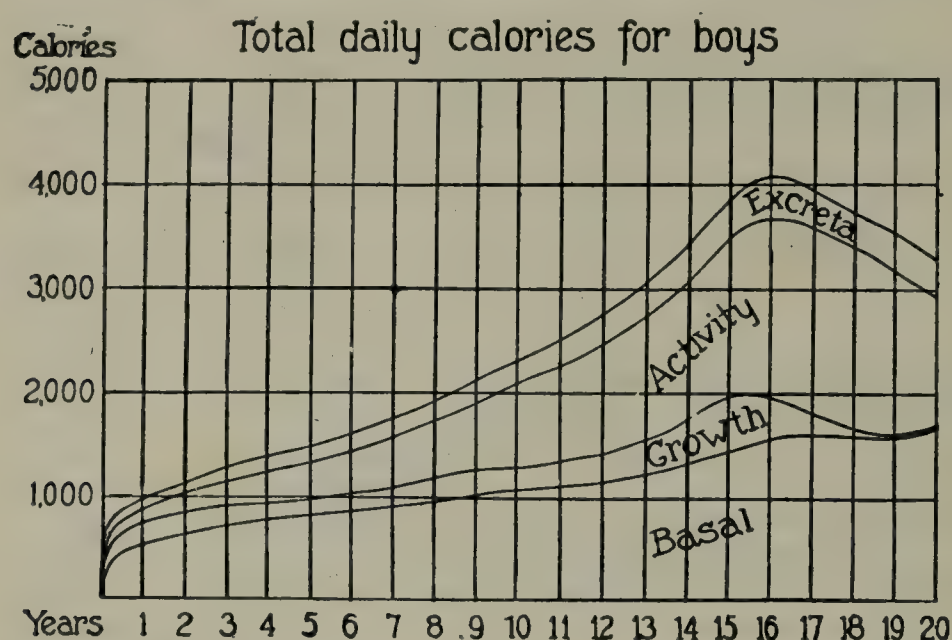


FIG. 14.—TOTAL DAILY CALORIES FOR BOYS FROM BIRTH TO TWENTY YEARS.

The ordinate under the upper curve shows the average requirement of total daily calories according to age, from birth to adult life. The spaces between the various curves, from the base line upward, indicate the allowance for the different factors which make up the total; namely, for basal requirement, growth, activity, loss in excreta.

infant is not possible. The data presented are, however, of value in that they furnish a rough guide as to the amount of food needed. Calculation of the calories enables one to discover whether a child is being grossly underfed or overfed.

**Protein.**—An adequate diet must contain protein, since this is the only kind of food that contains the structural units of protoplasm—the amino-acids. Of the twenty-two amino-acids now recognized as constituents of protein, nine are known to be essential for growth: lysine, tryptophane, histidine, leucine, isoleucine, phenylalanine, threonine, valine and methionine. Proteins which are relatively or totally lacking in one or more of these essential amino-acids are less valuable as food-stuffs than are the so-called "complete" proteins. In stating protein requirements it is, therefore, necessary to know the biological value of the type of protein which is to be fed.

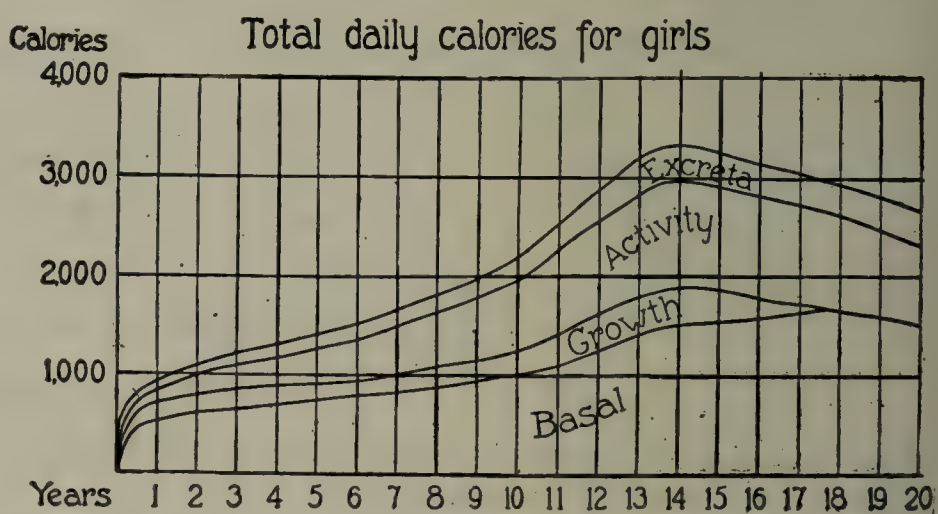


FIG. 15.—TOTAL DAILY CALORIES FOR GIRLS FROM BIRTH TO TWENTY YEARS.

The curves have the same significance as in Figure 14.

The growing child requires relatively more protein than the adult. The latter,



needing protein only for tissue repair, is in a state of nitrogen balance. The child, however, in the process of growth tends to retain nitrogen in considerable quantities and may do so even while losing weight. The nitrogen stored is all built into new tissue, since there is no accumulation of unorganized protein.

The absorption of protein split-products takes place, as in adults, from the intestine, and under ordinary circumstances this is fairly complete. The nitrogen of the stools is in some measure influenced by the food; but it is usually small in amount and derived largely from intestinal secretions and bacteria. The excess of amino-acids beyond the body requirements is burned in the body as fuel, the nitrogen being excreted in the urine. As much as 60 per cent of the ingested protein may be converted into glucose, which may be either burned or stored in the body.

When breast milk is the source of protein the requirements may be considered satisfied with an intake of 2.0 to 2.5 grams of protein per kilogram; this is what most nursing infants receive. The protein of breast milk is mostly lactalbumin, which is a complete protein (see page 102). Lactalbumin contains of all the proteins the highest proportions of the amino-acids leucin, lysin and tryptophan. Cow's milk contains less lactalbumin; its protein is largely casein, which is relatively poor in some of the essential amino-acids, notably in cystine. On this account infants who are artificially fed should receive a somewhat larger proportion of protein—between 3.0 and 3.5 grams per kilogram of body weight may be considered sufficient. These figures are ample for most animal proteins. Vegetable proteins as a class are, however, deficient. Many are totally lacking in one or more essential amino-acids. Although it is possible to secure adequate growth by mixtures of vegetable proteins, the quantities employed must be considerably larger than would be required with animal proteins.

After the period of infancy growth is relatively slower. Since, however, the vegetable proteins now form an important part of the diet, it is unwise to reduce the protein intake. Throughout the period of growth it is advisable that at least 3 grams of protein per kilogram be given to children on a mixed diet of vegetable and animal proteins. When animal proteins are used almost exclusively it would appear that about half this quantity is sufficient.

The symptoms of inadequate protein intake are not well defined, for diets low in protein are often deficient in other respects also. Infants so fed for prolonged periods may exhibit retarded growth, poor circulation, feeble musculature, increased susceptibility to infection and, at times, anemia. Perhaps the most characteristic manifestation is nutritional edema. This is associated with a low albumin and low total protein content of the blood, and responds favorably to protein feeding.

The effects of high protein intake are little to be feared. It was formerly believed that the high protein content of cow's milk was responsible for many digestive disorders in infants. When raw cow's milk is used, minor digestive disturbances may occur which appear to result from the firm large curds formed in the stomach; large bean-like curds may be found in the stools. Such phenomena are not encountered when the milk has been boiled, acidified or processed in other ways; they are not seen if starch is added to the milk. When casein is fed in large amounts, dry light-colored alkaline stools are produced which contain a high pro-



portion of minerals. This is used with some advantage in the treatment of certain forms of diarrhea.

It has been maintained that a large excess of nitrogenous products taxes the organs of digestion and excretion. Evidence is wanting that such is the case, under any ordinary circumstances. When excessively high protein diets are given with small amounts of water, fever and symptoms of intoxication may occur, but these are to be attributed to lack of water rather than to excessive protein. Such conditions are doubtless similar to the dehydration fever seen in newly born infants.

The problems resulting from hypersensitiveness to specific proteins in the diet will be taken up elsewhere.

**Fat.**—Fat is one of the most important constituents of the human body. The fat depots constitute reserves of energy which can be drawn upon in conditions of defective assimilation of food or starvation. According to Steinitz the body of a normal infant contains 12 to 13 per cent of fat; in severe nutritional disturbances it may fall below 1 per cent.

The normal breast-fed infant receives approximately half his calories in this form. Such a high proportion of fat is by no means a necessity, nor has it been thought desirable for artificially fed infants, for whom fat other than that of breast milk must be employed.

Since energy requirements may be met and adequate storage of fat accomplished by feeding protein and carbohydrate, it has been claimed that fat is not an essential food constituent. However, an attempt made in Vienna<sup>2</sup> to rear infants upon a fat-free diet met with very doubtful success. The indispensability of fats is chiefly due to the fact that they contain the fat soluble vitamins A and D (*q.v.*). Evidence has recently been brought forward, however, to show that animals will not thrive unless certain essential unsaturated fatty acids<sup>3</sup> (linoleic and arachidonic acid) are present in small amounts; the general nutrition suffers and skin lesions develop. Although such phenomena have not yet been observed in man, they furnish an added reason for providing a certain amount of fat in the diet. The vitamin content of food fats varies greatly. Little is known as yet in regard to their content of essential fatty acids.

It has been shown that the physical and chemical properties of stored fat are much influenced by those of the fat which is fed. The body fat at birth differs in many respects from that in later life; it contains less unsaturated fat, somewhat more of the shorter-chain volatile fatty acids, has a higher melting point, and is relatively poor in pigment. During the course of the first year,<sup>4</sup> the composition of the infant's fat gradually approaches that of the adult. On the assumption that the fat of human milk is ideally suited to the infant, various synthetic mixtures have been prepared for artificial feeding, in which certain of the physical and chemical constants of breast milk fat have been imitated. Without exception these imitations have been superficial ones; it has never been demonstrated that such fat mixtures possess any practical advantage. Moreover, the fat

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<sup>2</sup> von Gröer, *Biochem. Ztschr.*, 1919, 97: 311.

<sup>3</sup> Burr and Burr, *J. Biol. Chem.*, 1929, 82: 345; *ibid.*, 1930, 86: 587.

<sup>4</sup> Jaeckle, *Ztschr. f. physiol. Chem.*, 1902, 36: 53.



of breast milk is itself decidedly variable in composition, depending upon the mother's diet; it has been estimated that from 30 to 40 per cent of the milk fat represents unaltered fat of the diet.

Under normal conditions the absorption of fat is nearly complete. With breast milk from 90 to 98 per cent, with cow's milk from 85 to 95 per cent is retained by most infants. Even upon high fat diets the percentage retention is usually unaffected; the excretion is, however, much increased in diarrheal conditions. In health fats are excreted largely as soaps; in diarrhea chiefly as neutral fat, next as fatty acids with only a small amount as soaps. Urinary excretion of fat is negligible. It has been generally believed that cow's milk fat is less digestible for infants than woman's milk fat, but the evidence for this is very meager. Much emphasis has been laid upon the larger size of the fat droplets in cow's milk and upon the higher content of volatile fatty acids. Our own observations have indicated that the differences in the size of the fat globules are altogether negligible; moreover, there is little to indicate that the increase in volatile acids exerts any deleterious action. The slight differences in retention mentioned above are in part due to the higher mineral content of cow's milk, in part to the differences in the character of the fat itself.

The effects of a fat-poor diet have already been commented on. They are largely those of the associated vitamin deficiencies. Complete removal of fat from the diet usually leads to the formation of mushy, fermentative stools, perhaps because of the relative excess of carbohydrate. We have seen instances in which allergic manifestations appeared upon such diets, disappearing promptly as soon as the fat intake was increased. This phenomenon is probably related to the loss of water which occurs when fat is substituted for carbohydrate in the diet (see page 115).

An excess of fat in the diet may lead to failure of the appetite, to impaired motility and secretion of the stomach and to nausea and vomiting. It has been claimed that the prolonged use of a high fat diet may cause an intolerance for fat that may persist for years, but the evidence for this is by no means convincing. A high fat diet has been shown to divert a certain amount of mineral—particularly the alkaline earth minerals—to the stool in the form of soaps, but under most circumstances the resulting loss of mineral is small.

The combustion of fat is intimately related to that of carbohydrate. As it has been expressed, "fats burn in the flame of carbohydrates." If an inadequate amount of carbohydrate is being consumed, fats are incompletely oxidized and the ketone bodies, beta-oxybutyric acid, diacetic acid, and acetone may be formed, and may lead to acidosis. Ketone bodies may occur in normal individuals when the diet contains an excess of fat. They are produced during starvation when energy is derived chiefly from the fat depots of the body; they may also result from disorders of carbohydrate metabolism, such as diabetes, recurrent vomiting and in certain infections.

**Carbohydrates.**—Carbohydrates are the most convenient sources of energy available. Although a high carbohydrate diet has certain advantages, it cannot be considered a necessity. The eating habits of Eskimos and other exclusively carnivorous peoples show that a diet containing a minimum of carbohydrate is consistent with health and growth. Stefansson reports having seen infants successfully



reared on a diet of seal meat chewed by an adult and expectorated into the infant's mouth. Such a low carbohydrate regimen has definite limitations. When considerable fat is given, ketosis is likely to develop unless antiketogenic material is furnished in the form of protein or carbohydrate.<sup>5</sup>

The difficulty in feeding a low carbohydrate diet to young infants is in supplying in a digestible form the large amount of protein required for caloric needs. Even with cow's milk it is not always possible to do this. Prolonged feeding with raw cow's milk alone without addition of carbohydrate may lead to the symptom complex known in Germany as *Milchnährschaden*, in which nutrition suffers (see page 125). This has been attributed to a lack of carbohydrate in the food, but it is possible that it is due in part to an inability properly to digest the other food constituents present in relatively higher amounts. The condition is successfully treated by the addition of carbohydrate and a corresponding reduction of the protein and fat in the diet.

The carbohydrate of milk is lactose. Even young infants, however, can readily digest other sugars. Their tolerance for lactose is no greater than for other sugars, and it is therefore not clear why this special form of carbohydrate has been provided for them. It has been claimed that lactose has a favorable effect on the absorption of calcium and phosphorus, but certainly its superiority in this respect is not conspicuous. In infant feeding cane sugar is usually employed for reasons of convenience, and in most instances is entirely satisfactory. Mixtures of dextrans with some maltose are frequently used. The advantage of more gradual absorption is claimed for them, and they are said to ferment less readily in the intestine. The ability of the young infant to digest raw starch is practically nil; it is excreted unchanged in the stools. Cooked starch can, however, be digested to some extent even at birth. The ability to digest starch increases with age, and more rapidly when starch is fed. The addition of starch even in small amounts to raw cow's milk renders the casein curds much finer and more readily digestible. This is now less frequently employed, since the sterilization of milk for infant feeding has become almost universal. The addition of a larger quantity of starch renders the feeding solid or semi-solid, a useful measure in the treatment of vomiting.

Under normal conditions carbohydrates are absorbed only as monosaccharides. Disaccharides and polysaccharides must first undergo hydrolysis in the intestine. Only monosaccharides can be utilized when introduced parenterally; other sugars are excreted<sup>6</sup> unchanged in the urine. Monosaccharides are built up into glycogen, which is stored in the liver and muscles if not needed for immediate energy

<sup>5</sup> The production of ketosis has been shown to depend upon the ratio of *ketogenic factors* (chiefly fat) to *antiketogenic factors* (chiefly carbohydrate) in the diet. This may be calculated according to the formula of Woodyatt:

$$\frac{(\text{protein} \times .46) + (\text{fat} \times 0.9)}{\text{carbohydrate} + (\text{protein} \times .58) + (\text{fat} \times 0.10)}$$

or according to the formula of Shaffer:

$$\frac{(\text{urinary N} \times 15) + (\text{fat} \times 3.43)}{(\text{carbohydrate} \times 5.56) + (\text{urinary N} \times 20) + (\text{fat} \times 0.57)}$$

In either case the constituents are expressed in grams. Ketone bodies usually appear in the urine when the ratio according to Woodyatt exceeds 1.0, or when the ratio according to Shaffer exceeds 0.8. This is in marked contrast to the adult, in whom approximately twice as much ketogenic substance is required to produce ketonuria. (Wilson, Levine and Rivkin, *Am. J. Dis. Child.*, 1926, 31: 335.)

<sup>6</sup> Maltose appears to be an exception to this rule. It is partially utilized when introduced parenterally.



requirements. Excess of carbohydrate may be converted into fat. The sugar of the blood is almost entirely dextrose (d-glucose). It is normally maintained between 0.075 and 0.110 per cent by means of the glycogen reserve in the liver, glycogen being synthesized from the blood sugar in the case of an excess, or hydrolyzed to form dextrose when the blood sugar tends to fall. The ingestion of sugar causes a rise in the blood sugar. If the latter exceeds 0.20 per cent, sugar usually appears in the urine. The tolerance of infants for glucose appears to be slightly greater than that of adults; a larger amount may be given in proportion to the body weight before glucose appears in the urine. The level at which the blood sugar is maintained is, however, less constant than with adults. In many individuals it tends to fall below 0.06 per cent from apparently trivial causes, usually associated with some degree of starvation. Symptoms of hypoglycemia may then appear (see page 282). In the first few days of life and in premature infants a low blood sugar unassociated with symptoms of hypoglycemia is not infrequently found. The explanation of this is not altogether clear. It has been attributed by van Creveld to patency of the ductus venosus. (See page 9.)

The combustion of carbohydrate occurs only through the agency of insulin. The production of insulin is in some degree dependent on the amount of carbohydrate ingested; practically only in diabetes mellitus does this regulation break down. When large quantities of carbohydrate are administered for therapeutic purposes, however, it is sometimes advisable to give additional insulin to insure combustion.

The difficulties encountered with low carbohydrate diets have already been commented on. Concerning the effects of high carbohydrate diets there has been a great divergence of opinion. It was formerly believed that an excess of carbohydrate fermented in the intestine, and that the resulting lower fatty acids caused irritation and led to the production of diarrhea. This statement is only partly true. Such fermentation may at times occur when the lower sugars are fed; it is less likely to happen with mixtures of dextrin and maltose. It does not happen if carbohydrate is fed in the form of starch. But such fermentation when it does occur may well be the result rather than the cause of the nutritional disturbance. In the normal individual, sugar is tolerated in large amounts. In the presence of infection, however, this tolerance breaks down and fermentation of unabsorbed sugar may occur.

It cannot be said that sugars as a class are laxative, although a number of commercial carbohydrate preparations do have this effect. This is particularly true of some of the preparations of lactose and of the liquid malt preparations. The laxative effect can be attributed to impurities rather than to the sugar itself.

A diet with too large a proportion of carbohydrates often leads to a rapid increase of weight, but it is not accompanied by a proportionate increase in strength. Infants so fed are flabby, they have little resistance to infection, often they develop rickets. The condition is sometimes designated as *Mehlnährschaden*. It is not to be regarded as a carbohydrate injury, however, but rather as a deficiency of other foodstuffs—proteins and vitamins. The easy digestion of foods consisting largely of soluble carbohydrates such as sweetened condensed milk and many proprietary infant foods, and the rapidity with which children so fed gain



in weight led to a great misunderstanding of their value as foods. The ultimate results of such one-sided feedings, if they are long continued, are likely to be unfortunate.

**Percentage Distribution of Calories.**—It is apparent that an optimum value for the distribution of calories as protein, fat and carbohydrate cannot be given; a wide range of variation is compatible with a balanced ration. The distribution of calories in breast milk—protein 8 per cent, fat 46 per cent, carbohydrate 46 per cent—is not to be taken as a guide in artificial feeding. Such a low protein intake is permissible only when the protein has a high nutritional value; such a high fat intake is perhaps advisable only when the fat is particularly well adapted to the digestion.

Observations made by Holt and Fales on normal children taking a mixed diet showed that the average intake was: 15 per cent of the calories as protein, 35 per cent as fat and 50 per cent as carbohydrate. It is a curious fact that the most successful cow's milk mixtures used for infant feeding have a distribution of calories closely approximating this. While one should not hesitate in the presence of particular indications to employ a diet quite different from this, in the absence of such indications it would appear that these figures can be regarded as an average normal which may well be followed.

**Vitamins.**—This name is used to designate the several accessory food factors, the absence of which from the diet gives rise to various diseases or syndromes. They occur in various natural foods in quantities so small that until recently they have defied chemical analysis. A knowledge of their distribution and properties is essential in the study of nutrition.

Claims have been advanced for the identification of some eight or ten vitamins. Not all of them are universally accepted, but at the present time at least six accessory factors, associated with as many deficiency diseases (avitaminoses), are generally recognized:

1. Vitamin A, lack of which leads to xerophthalmia (keratomalacia) and night blindness
2. Vitamin B ( $B_1$  in British literature), lack of which leads to beriberi
3. Vitamin C, lack of which leads to scurvy
4. Vitamin D, lack of which leads to rickets
5. Vitamin E, lack of which leads to sterility in rats and in mice
6. Vitamin G (British  $B_2$ ), lack of which leads to pellagra.

*Vitamin A.*—The chemical structure of this factor, formerly known as fat-soluble A, has only recently been elucidated. It is closely related to the pigment carotene, which is widely distributed in the vegetable kingdom. Ordinarily, carotene or some similar substance acts as a precursor, and after ingestion is made into vitamin A in the animal body, probably in the liver. It is most abundant in fish liver oils, such as those of the halibut, tuna and cod; it is present in many animal fats, such as that of milk, egg, liver and kidney. The quantity in milk seems to be dependent on the amount of the vitamin or carotene ingested. Lard and vegetable oils are notoriously poor in their content of the A factor. In the absence of oxygen it is fairly resistant to heat, but the passage of air through cod liver oil for twelve hours at  $100^\circ$  C. destroys all vitamin A. Excessive irradiation with ultraviolet light appears to be harmful. Sterilization of milk and cooking of vegetables does



not materially injure their content of this vitamin. A deficiency of the A factor results in general malnutrition and lowered resistance of infection; the eyes in particular are involved in a low grade conjunctivitis with a marked tendency to softening and ulceration of the cornea (keratomalacia). The clinical picture of vitamin A deficiency is described in more detail elsewhere.

*Vitamin B.*—The water-soluble, antineuritic vitamin has been isolated by Jansen and Donath, and by others, as a crystalline hydrochloride having the formula  $C_{12}H_{18}O_2N_4SCl_2$ . This factor is widely distributed in nature; it is found in vegetables, fruits, egg, and in the whey of milk; it is particularly abundant in brewer's yeast and in the germ of grains; it is, however, absent from the endosperm of the grain and is therefore lost in the process of milling. The quantity present in milk is dependent on the mother's intake of this vitamin. Ordinary cooking does not injure it. Absence of the B factor leads to beriberi, a disease characterized by polyneuritis; it is rare in Western countries, but in the Orient where polished rice forms the bulk of the diet it is exceedingly common. It has been claimed that many infants suffering from malnutrition and loss of appetite are in reality suffering from a mild deficiency of the B factor. Convincing evidence for this has yet to be presented.

Associated with the antineuritic vitamin in yeast are at least two other factors. An extract containing these was found by Goldberger to cure human pellagra, and the potent factor was designated vitamin G in this country and vitamin B<sub>2</sub> in Europe. Other growth-promoting B factors have been suggested, but on disputed grounds.

*Vitamin C* (ascorbic acid, cevitamic acid) was isolated in 1932 by Waugh and King and by Szent-Györgyi and identified with a "hexuronic acid" previously obtained by Szent-Györgyi from the adrenal gland. It is a colorless, crystalline substance of lactone structure with the formula  $C_6H_8O_6$ . It is widely distributed in the body, being most abundant in the adrenal cortex. It occurs in relatively high concentration in the juice of the citrus fruits, particularly orange juice. Other foods rich in this vitamin are the tomato, yellow turnip (swede) and cabbage; it is found in smaller amounts in all green vegetables and in potato. Milk contains relatively little, and this may be further reduced by various procedures to which it is subjected. Ascorbic acid is a powerful reducing agent and is destroyed readily by atmospheric oxygen, especially in an alkaline medium. Its destruction is accelerated by heat, by various oxidizing agents, by exposure to light, and by certain catalysts, particularly copper. The active principle is not necessarily damaged in the drying of milk or in the canning of foods.

*Vitamin D.*—The antirachitic factor differs from other vitamins in the fact that its presence in the food is not always essential; if the body is exposed to sunshine or some other source of ultraviolet radiation, there is no need for giving this vitamin. Certain foods—yolk of egg, the fish oils, and especially cod liver oil—contain it in abundance; a variable amount is present in the fat of milk. Other substances having no demonstrable antirachitic action may be rendered effective by irradiation with ultraviolet light. This property of acquiring antirachitic potency on irradiation is possessed in extreme degree by ergosterol; preparations of irradiated ergosterol have been obtained having an antirachitic activity 100 million



times that of cod liver oil. Until recently irradiated ergosterol was thought to be vitamin D itself, but it now appears that certain other sterols are capable of being rendered antirachitic, and it becomes necessary to speak of *antirachitic substances*, rather than of a single vitamin. The potency of these preparations is ordinarily expressed in rat units. The various agents are not alike when used in different animal species; preparations equally effective in the rat are known to differ widely in potency when used in the chick. Whether rat units are strictly applicable to man remains uncertain. The antirachitic effect of direct ultraviolet irradiation of the skin appears to be due to the activation of sterols in the skin.

The natural sources of vitamin D are stable, and the same may be said of the commercial preparations of pure ergosterol in lipoid solution and of many substances activated by irradiation. Common cooking procedures do not affect them appreciably. Under other conditions when freed from lipoid media this vitamin may be very unstable; all its potency may be lost suddenly and without warning.

*Vitamin G.*—The observations of Goldberger suggest strongly that lack of this vitamin is a factor of great importance in the causation of pellagra. He has produced in experimental animals a condition very similar to pellagra which responds promptly to the administration of this vitamin. Goldberger's factor has recently been differentiated into a rat growth-promoting substance closely akin to the flavine pigment present in whey, egg-white, liver and other tissues, and a colorless product to which the antipellagra activity has been ascribed.

**Minerals.**—These have been the last of the food constituents to receive attention. Although they are not sources of energy, they are absolutely indispensable for life and growth. They are the chief constituents of the body fluids and play an important part in regulating the processes of absorption and excretion, the osmotic equilibrium, the acid-base equilibrium and other physiological adjustments. They constitute the greater part of the bony framework of the body. They are essential not only to the structure but to the function of living tissue throughout the body.

Since mineral salts are being continually excreted, even during starvation, they must be regularly supplied. The body fluids serve to some extent as mineral

TABLE XII  
TOTAL DAILY RETENTION OF MINERALS  
(In millimols)

	Na	K	Ca	Mg	Cl	P	S	N
On breast milk .....	2.4	2.5	1.0	0.3	2.0	1.1	0.45	38.6
On cow's milk .....	5.2	4.9	5.1	0.7	5.5	3.7	0.27	66.3

reservoirs, but they are readily depleted. Unless salts are supplied in adequate amounts water cannot be held by the body and dehydration ensues.

The adult requires minerals for maintenance only. The child needs, in addition, minerals for the construction of new tissues and body fluids; the requirements of the child are even further increased by the fact that his metabolism is more active.

The figures in Table XII, taken from Swanson, illustrate the retention of minerals by infants during the first six months of life.



Table XIII gives the mineral retention in relation to increase in body weight:

TABLE XIII  
RETENTION OF MINERALS PER KILOGRAM OF INCREASE IN BODY WEIGHT \*  
(In millimols)

	Na	K	Ca	Mg	Cl	P	S	N
On breast milk .....	104	108	39.6	12.2	88	49.4	19.9	1690
On cow's milk .....	205	190	198	28.4	214	145	10.3	2599

\* The figures for nitrogen retention are given for purposes of comparison.

These figures show that the retention of minerals is greatly influenced by the intake. An infant fed on cow's milk, with its high mineral content, retains a proportionately larger amount. Only in the case of sulphur, an element which is relatively low in cow's milk, is a smaller amount retained. The evidence available indicates that the retention of excess mineral, as occurs on a cow's milk diet, is not in the least harmful; it may continue for many months, perhaps until growth is complete.

It is not possible to give exact figures for mineral requirements. If the retention figures for breast-fed infants be taken as a minimum upon which satisfactory growth is obtained, the minimal dietary requirement is probably twice this, for only approximately half of the ingested material is retained.

It was formerly held (Bunge) that minerals were absorbed in a definite ratio one to another. This is now known not to be the case. Sodium, potassium, calcium or iron are absorbed and retained each quite independently of the other.

*Sodium and Chlorine.*—Sodium and chlorine are the chief constituents of the body fluids; they play a negligible part in the structure of body cells. They are the important elements concerned in the maintenance of osmotic pressure and water exchange in general; they are of prime importance in maintaining the electrical environment of the tissues. Both sodium and chlorine are absorbed almost quantitatively from the intestine. Normally only very small amounts of these elements are found in the stools. The excess above body requirements is readily secreted in the urine. In pathological conditions the absorption of one or both of these elements may suffer, and considerable amounts may be found in the stools. In celiac disease large amounts of Na and Cl may be excreted in the feces. A diet high in fat may cause a considerable loss of sodium in the stools in the form of soaps. In diarrheal conditions, owing to faulty absorption from the intestine, marked losses of Na and Cl occur in the stools; these are in part derived from the food, in part from the intestinal secretions. Since the latter are alkaline, containing more sodium than chlorine, the stools may contain a marked excess of sodium. This loss of fixed base is an important factor in causing the acidosis frequently associated with diarrhea. Gastric secretions on the other hand contain much more chlorine than sodium. In cases of persistent vomiting the loss of acid by this means may lead to alkalosis.

*Potassium.*—Potassium is present in only small amounts in the extracellular body fluids; it is the chief basic constituent of the body cells and is consequently



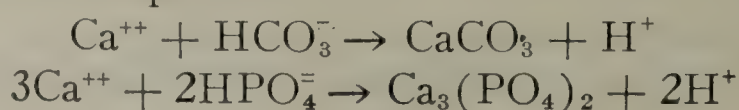
required in large amounts. Absorption of potassium from the intestine is somewhat less complete under normal conditions than is the case with sodium and chlorine; most of it is, however, absorbed, the excess appearing in the urine. On a mixed diet, somewhat more K is lost in the stools. As is the case with sodium, an excessive amount of potassium may be lost in the stools when the diet is high in fat, and in diarrheal conditions where the opportunity for absorption is limited.

Conditions in which there is a deficiency of potassium have not as yet been described. An excess of potassium is not to be feared on any ordinary diet. The administration of potassium by mouth is a safe procedure in the presence of normal renal function, but should be avoided if there is any question in regard to this. In such circumstances the potassium in the plasma may rise, and there may be exerted a deleterious action on the heart.

*Calcium.*—Calcium is required in large amounts for the formation of bone; it plays an integral part in controlling the excitability of nervous tissue, a lack of calcium leading to the development of tetany. The metabolism of calcium presents a number of peculiarities. Like the alkali metals the absorption of calcium may be interfered with by the presence of considerable fat in the diet, resulting in the formation of insoluble calcium soaps. Unlike sodium and potassium, however, calcium forms insoluble compounds with other ingredients of the intestinal contents, notably with phosphate, to a lesser extent with carbonate. Much of the calcium in the intestine is hence in an insoluble form; a comparatively small fraction is soluble and available for absorption. The administration of phosphate or any other radical capable of forming an insoluble or un-ionizable compound with calcium decreases the amount of calcium available for absorption and may lead to tetany. An acid reaction tends to repress the ionization of such ions which unite with calcium; acidity therefore increases the available calcium, while alkalinity interferes with its absorption. The absorption of calcium as well as that of phosphorus is greatly increased by vitamin D in physiological doses or by ultra-violet radiation of the body; the mechanism by which this is accomplished is not clear. Under normal conditions the calcium of the blood serum is maintained at a constant level of about 10 milligrams per 100 c.c. (2.5 millimols per liter). The parathyroid hormone plays an important part in maintaining this level. A diminution of the blood calcium due to parathyroid deficiency or to other factors brings on tetany.

In general it may be said that the intake of calcium is a matter of minor importance in regulating the calcium metabolism. Intake may vary within wide limits without physiological effect if parathyroid function is normal and if vitamin D is not deficient; exceptions to this are few. When these regulating mechanisms break down, however, comparatively minor variations in the intake may produce noticeable effects.

If calcium salts of strong acids are given in large amounts, an acidosis may result. This acidotic effect of calcium results from its ability to combine with basic radicals to form insoluble compounds:





*Magnesium.*—Small amounts of magnesium are found in the blood and in bone. Its metabolism is in many respects analogous to that of calcium; it tends to form insoluble compounds in the intestine, so that only a small part of the magnesium present is absorbed, the remainder being excreted in the stools. Vitamin D and parathyroid hormone appear to be without influence on the metabolism of magnesium.

Little is known in regard to the functions of magnesium. In many respects its action is antagonistic to that of calcium. Given in excess it has a sedative action upon the nervous system. Although both calcium and magnesium will relieve the symptoms of tetany their action in this respect is not identical, for an overdose of magnesium can be successfully treated by the administration of calcium. It has been shown that magnesium interferes with the calcification of bone. Of interest in this connection are the observations of Howe who has found that carious teeth contain double the normal quantity of magnesium.

*Iron.*—This element is of great importance since it forms an essential part of the hemoglobin molecule. The small quantity of iron in breast milk and cow's milk would, if entirely absorbed, meet the needs of the growing infant; but owing to incomplete absorption, milk does not provide sufficient iron. During the period of milk feeding the deficiency in iron is made up from stores in the liver laid down in the last few weeks of fetal life and in the neonatal period. The premature infant, who has a relatively low store, must be given iron at an early date; otherwise he is likely to develop a severe anemia. With the full term infant it is advisable to give iron in some form from the seventh month onward. It was formerly supposed that organic compounds of iron were of particular value in the synthesis of hemoglobin. Recent evidence, however, indicates that inorganic compounds and even metallic iron are quite as effective.

*Copper.*—It has lately been shown that copper has a definite catalytic action upon the synthesis of hemoglobin.\* The addition of copper brings about a far more rapid response in hemoglobin formation in nutritional anemia than does iron alone; in the absence of iron, copper has no such effect. Whether copper plays any part in normal physiology has not as yet been ascertained.

*Phosphorus.*—This element serves many functions in the body. It is an important constituent of all body cells, where it exists in organic combinations; it is particularly abundant in nervous tissue. Inorganic phosphate is the chief mineral constituent of bone. The acid-base equilibrium of the body is in part regulated by the phosphate buffers of the blood. Phosphorus, moreover, is intimately concerned with the combustion of carbohydrate.

Although some phosphorus is ingested in organic combination, the greater part in the diet is inorganic. The phosphorus in milk is almost all inorganic. Its absorption is intimately related to that of calcium, as has already been pointed out; an increase in the calcium intake will cause the precipitation of more calcium phosphate in the intestine and the absorption of phosphorus is then diminished. Acidity favors the absorption of phosphorus, as does vitamin D and ultraviolet radiation of the body. Parathyroid hormone does not appear to influence the absorption of phosphorus, but it increases its excretion in the urine.

The amount of phosphate in milk and in most diets is ample; one need not fear



a lack of this element. An excess of phosphate causes no harm if the kidney function is normal. With some types of renal insufficiency acid phosphate is retained and tends to accumulate in the blood causing an acidosis.

Elementary phosphorus has been used extensively in the treatment of rickets. We do not believe that it is of value. Phemister has shown that it exercises a specific influence on bone growth, producing a multitude of fine trabeculae near the epiphyseal line. Phosphorus poisoning has at times resulted from overenthusiasm for this form of treatment in rickets.

*Sulphur.*—Sulphur is an essential constituent of the diet. It is ordinarily ingested as the amino-acids cystine and methionine; it is now clear that only the latter of these two compounds is indispensable. Sulphur compounds are present in a number of tissues. Probably the most important of these is glutathione, discovered by Hopkins. This substance is present in small amounts in nearly all tissues and plays an important part in physiological oxidations.

*Iodine.*—In minute amounts iodine is a necessary constituent of the diet. Its importance in infancy is, however, not paramount, for goiter seldom develops at an early age.

**Acid-base Balance.**—The ash of the human body contains an excess of basic over acid radicals. The same is true of both cow's and woman's milk; from this point of view, milk may be considered a physiological food. The mineral content of other foods varies greatly; meat, eggs, potatoes, cereal grains contain an excess of acid radicals, while the ash of fruits and green vegetables contains an excess of base. Under all ordinary conditions, the excess of minerals in the diet is so great that there is ample opportunity for the body to select the basic and acid radicals it requires and to excrete the remainder; an acidosis or alkalosis of dietary origin is not to be feared. However, when the acid-base equilibrium is distorted from some other cause, the intake of mineral base and mineral acid may become a matter of importance.

**Water Metabolism.**—Water is required for the assimilation and elimination of metabolic products, for the regulation of temperature and for the construction of tissue. In proportion to his body weight the infant requires considerably more water than does the adult. His metabolism is more active, the intake of foodstuffs and minerals being relatively two or three times as great as that of the average adult. Only a small amount of the water intake is required for growth.

Most nursing infants receive from 125 to 150 c.c. of water per kilogram each day (2 to 2¼ ounces per pound). This may be taken as an optimum requirement; it undoubtedly provides a liberal margin of safety, for such infants may tolerate warm weather or attacks of febrile disease without adverse symptoms. The minimum requirement for breast-fed infants has never been accurately determined.

The water requirement is to a considerable extent influenced by the food. When more food is given more water is required for the elimination of the waste metabolic products and inorganic components of the diet. A diet high in protein requires more water than a low protein diet, because of the marked "specific dynamic" effect of proteins and the increase of nitrogenous waste products which must be excreted. Since cow's milk diets contain more protein and more minerals, it follows that the minimum water requirement is somewhat higher than is the



case with nursing infants. Schoenthal has made observations on the minimum water requirements of artificially fed infants. Symptoms of acute dehydration, fever, prostration and loss of weight appeared when the water intake was reduced to between 35 and 60 c.c. per kilogram ( $\frac{1}{2}$  to 1 ounce per pound). It is thus apparent that, with a water intake no greater than that of the nursing infant, the artificially fed child is still provided with a generous reserve of fluid.

During the first six months of life it is probably unwise to decrease the water intake below that of nursing infants. Whether the water is given with the feeding or between meals is, as a rule, a matter of indifference. The practice of giving undiluted cow's milk formulae, which has become increasingly prevalent in late years, carries with it the need of giving water between meals, if the water intake is to be maintained at this level. In an institution such a procedure may be made a routine one, and is unobjectionable. In the home, however, this adds to the care of the child, and is often neglected; moreover, some infants do not take water between meals readily. For the majority of infants, dilution of the milk seems to be the most satisfactory way of insuring a proper water intake. With a small minority it is advantageous to keep down the volume of the feeding; water may then be given between the meals.

There appears to be no advantage in increasing the water intake above the value stated; the result is merely the passage of a large amount of dilute urine. With older children, the fluid requirements are less; the appetite is usually a satisfactory guide to follow.

Ordinarily from 30 to 65 per cent of the water ingested is eliminated by the kidneys, 65 to 30 per cent by the lungs and skin, 2 to 7 per cent by the intestine and 1 or 2 per cent is retained for growth. Obviously there is no constancy in the percentage excreted by these different routes. Exercise, clothing and climate may greatly influence the excretion of water through the lungs and skin. Fever increases the elimination through the skin and lungs at the expense of the elimination through the kidneys. In diarrhea large amounts of water may be lost through the bowel. A variety of other pathological conditions may affect the water elimination.

The body of the newly born infant consists of about 70 per cent water; that of the adult of about 58 per cent. The marked variation in the weight of infants, when daily observations are made, is due largely to fluctuations in water retention. Retention of water is greatly influenced by the administration of salt, particularly sodium chloride. A sudden gain in weight, due to retention of water and minerals, is often observed when carbohydrate is substituted for fat in the diet; this has often caused misconceptions as to the value of low fat, high carbohydrate diets when attention has been too closely focused upon the weight curve. The explanation of this phenomenon is obscure; it has been attributed to a storage of water associated with glycogen in the liver. Such an interpretation is, however, quite inadequate to explain the amount of water retention that may occur. The water so stored seems to be loosely held; an acute infection may cause it to be rapidly lost, even in the absence of diarrhea.

A further discussion of the causes and treatment of dehydration is given elsewhere (page 191).



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## CHAPTER XII

### DIGESTION IN INFANCY

The infant is at a distinct disadvantage as regards digestion. His food requirements are relatively greater than those of the adult, and his digestive capacity is more limited. Although his tolerance for foodstuffs may be as great as that of the adult, it is far less stable, particularly as regards carbohydrates and fats. A variety of factors, particularly infections and external heat, may have a deleterious effect on the digestive powers of the infant. Under such conditions his tolerance may be so diminished that adequate maintenance is not possible.

For a general discussion of the mechanics and chemistry of digestion the reader is referred to treatises on physiology. The present work will deal only with peculiarities encountered in early life.

**Mechanical Factors.**—Since the infant cannot masticate, his food must be presented to him in a highly subdivided state. Solids are given in solution or suspension, which involves the ingestion of a large volume of fluid. The capacity of the infant's stomach is limited, hence he must be fed many times a day.

In the nursing infant, food begins to leave the stomach almost at once; within five minutes a considerable part has often reached the intestine. After half an hour the greater part has passed through the pylorus; the stomach is usually completely empty in two to two and one-half hours. The emptying time is influenced by the size of the meal and by the character of the food. The presence of large curds or a high percentage of fat may prolong it.<sup>1</sup> In artificially fed infants the emptying time of the stomach is likely to be somewhat prolonged, particularly if raw cow's milk is fed; half an hour or an hour more may be required. In older children upon a mixed diet the stomach often contains food at the end of four hours, but is regularly empty after five hours. Gastric motility is influenced unfavorably by fever, infections, rickets and states of malnutrition. Rogatz has shown that the presence of semisolid food in the stomach tends to increase the tone of the stomach as a whole (peristolic function). Disturbances of the gastrointestinal tract—particularly diarrhea and vomiting—are more frequently met with than in adults.

**Digestive Secretions.**—*Salivary digestion* is unimportant in young infants. The quantity of saliva and of salivary diastase at birth is small; after the third month, and earlier if starch is fed, the quantity and the amylolytic power of saliva are increased.

The *gastric secretions* of the infant are particularly susceptible to pathological influences; such conditions as fever, infections and external heat may cause a

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<sup>1</sup>Fats inhibit both the motor and the secretory activity of the stomach. Roberts (*Quart. J. Med.*, 1931, 24:133) has recently shown that the inhibitory effect is proportional to the iodine number of the fat, the more unsaturated fats exerting a more pronounced effect. The influence does not seem to be a direct one, for inhibition of gastric function occurs only after the fat has begun to pass out of the stomach.



great reduction in the output of both hydrochloric acid and digestive enzymes. Gastric digestion seems to be less important in infancy than in later life. The output of HCl by the infant's stomach is relatively small; although a high fasting acidity may be found shortly after birth,<sup>2</sup> the pH of the gastric contents after feeding is considerably above the values found in adults. The ingestion of food causes the stomach to secrete acid; the pH of the gastric contents gradually decreases. With breast-fed infants it usually lies between 3.5 and 4.0 at the end of one hour; since the optimum pH for the activity of pepsin is below 3.0, comparatively little peptic digestion can take place. When cow's milk is fed, the reaction of the gastric contents tends to be even less acid; the pH may be above 5.0. The reason for

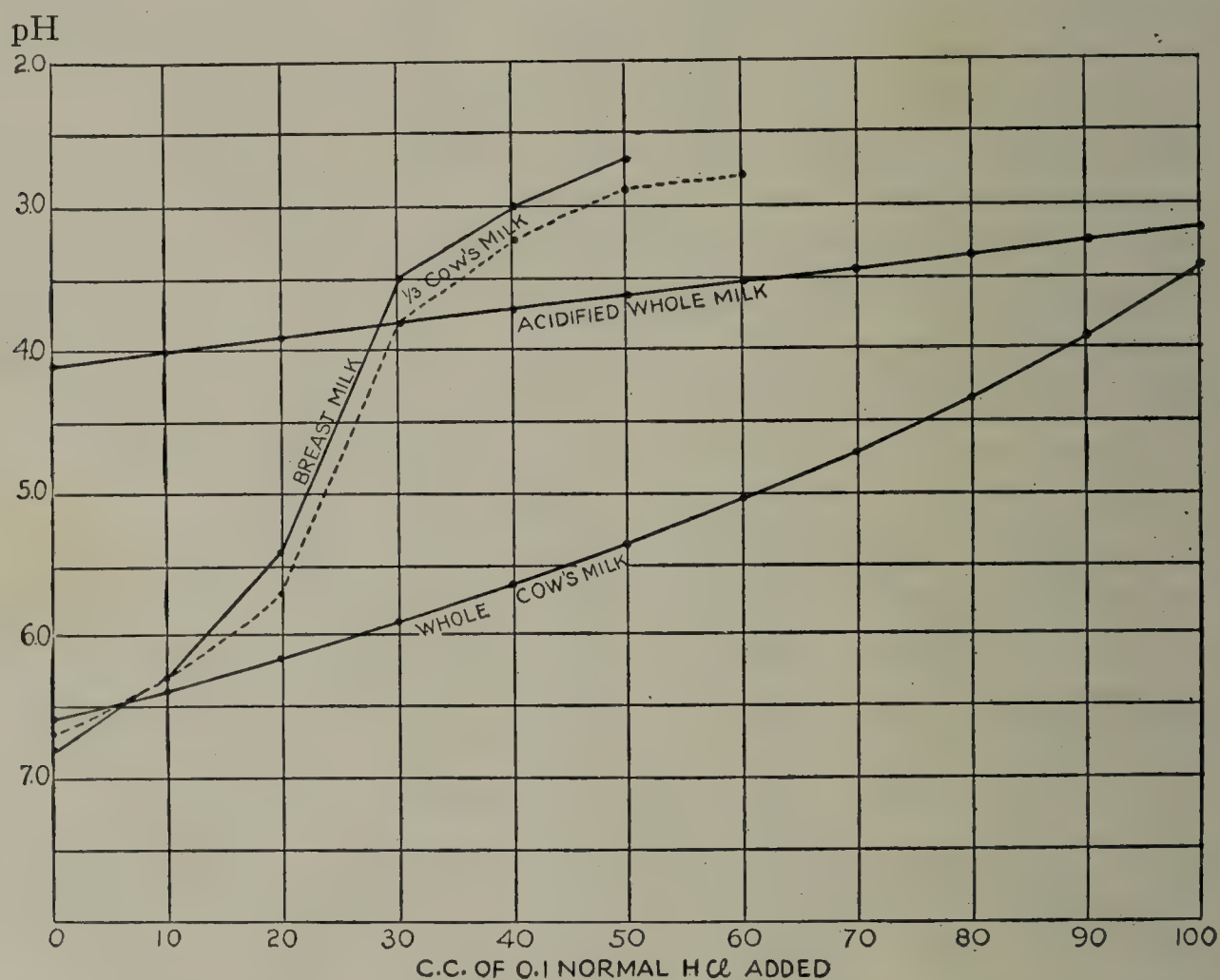


FIG. 16.—TITRATION CURVES OF MILK, SHOWING BUFFER EFFECT WITH DIFFERENT KINDS OF MILK.

(After Marriott and Davidson, *Am. J. Dis. Child.* 1923, 26: 542.)

this is that cow's milk has a higher "buffer value" than breast milk. It contains more protein and more phosphates, substances which are capable of combining with acid and preventing an increase in acidity. The titration curves in Figure 16 illustrate the difference in the buffer value of cow's milk and breast milk.

The majority of infants on a diet of cow's milk tend to overcome this greater buffer effect by the secretion of more acid; with many infants sufficient acid is secreted to compensate for it entirely, the pH of the gastric contents being no higher than on breast milk; with other infants compensation is only partial. Many of the digestive disorders of artificially fed infants have been attributed to the increased buffer value of cow's milk; it has been claimed that the lowered acidity of the gastric contents handicaps the digestion of the infant, and that, when com-

<sup>2</sup> Griswold and Shohl found an average pH of 2.6 in fasting newly born infants.



pensation is complete, the additional secretion of acid is a drain upon the acid-base equilibrium of the body. An "alkaline tide" after meals can often be detected in the blood of artificially fed infants, but the same is true of the adult.

When all is said and done, it must be admitted that no evidence has yet been produced to show that the normal infant fed on sweet cow's milk is in any way harmed by reason of its higher buffer value. In pathological conditions, when gastric secretion is likely to be diminished, it would appear that "acid" milks—those which have either undergone acid fermentation or to which acid has been added—may be of distinct benefit.

Coagulation of the casein invariably occurs in the stomach. Loose flocculi are formed in the case of woman's milk. With raw cow's milk, the curds are larger, firmer and more compact; they are less readily digested than those of woman's milk. They may, however, be greatly modified and rendered more digestible by various procedures used in the preparation of the feeding. Dilution produces smaller curds. When milk has been heated, the coagulum tends to resemble that of woman's milk. By pasteurization comparatively little change is effected, but when the heating has been carried to a higher temperature, as is the case with boiled milk, dried milk or evaporated milk, the curd is greatly altered and rendered more digestible. The addition of starch, of alkalis, and of salts which may bind calcium tends to produce finer curds. Fermentation or the addition of acid to milk causes precipitation of the curd outside the body; the type of curd formed varies with the procedure used, but under appropriate conditions very fine, homogeneous curds may be produced. Such digestion as takes place in the infant's stomach is confined almost entirely to the proteins. Practically no absorption of any foodstuff occurs.

Like the gastric juice, the *pancreatic secretion* of infants is susceptible to a variety of pathological conditions. Marked reduction in the enzymes may occur and may play a part in producing nutritional disturbances and indigestion. The pancreatic juice, the bile, and the succus entericus are all alkaline in reaction. However, the reaction even in the duodenum is often on the acid side of neutrality.

Studies of the electrolyte content of the digestive secretions have been carried out, notably by Gamble and McIver. The pancreatic juice, the bile and probably the succus entericus as well contain an excess of fixed base over fixed acid, this excess being balanced by bicarbonate. During normal digestion, the ingredients of these secretions are almost completely reabsorbed and conserved by the body. In the presence of diarrhea, however, the rapid peristalsis may not allow sufficient time for this reabsorption to take place; an excess of base may thus be lost by the body leading to the production of acidosis.

**Digestion and Absorption of Foodstuffs.**—The young infant's gastrointestinal tract is ordinarily free from inert residue. A certain amount of this material is ingested in a finely divided state when scraped meats, strained vegetables, and unrefined cereals are added to the diet. Its presence does not, however, interfere with digestion unless the particles are coarse. The chief reason for subdividing the infant's food is to enable him to obtain the nourishment from it. Occasionally, large, undigested masses may provoke a digestive upset.

The digestion and absorption of proteins is remarkably complete, even in the presence of severe disease. It is seldom that undigested protein appears in the



stools, although amino-acids are found in small amounts. The bulk of the nitrogen of the stools is contained in the bodies of bacteria. Although absorption takes place almost entirely as amino-acids, there is some evidence that the lower peptides may be taken up normally in small amounts. Under certain conditions traces of unsplit protein may be absorbed; the amounts, however, are so small as to be recognizable only by specific biological tests. Contrary to the belief once held, the infant can tolerate a high protein intake without digestive disturbances or renal damage resulting. There is little reason for giving such a diet, except in unusual circumstances, as when vegetable proteins are employed. With a high protein intake more water is required; failure to provide this may lead to dehydration fever.

The tolerance of the infant's digestion for carbohydrate foods is high. Except in early infancy starch is well digested. If fed in excess it appears unchanged in the stools, producing no disturbance. Unabsorbed sugar does not, however, appear in the stools. It is attacked by bacteria with the formation of volatile fatty acids. Under normal conditions comparatively little sugar is fermented. Even when a large quantity is ingested, it is well absorbed and may result only in alimentary glycosuria. In conditions of disease, however, the absorption of sugar is readily impaired; a considerable part is fermented and there is a marked increase in the volatile fatty acids of the stool. Diarrhea has been ascribed to the irritating action of these acids when present in excess. There are, however, reasons for questioning this view. Alterations of the carbohydrate intake will cause marked changes in the volatile fatty acid output, but will not produce corresponding variations in the severity of the diarrhea. The use of particular sugars has been advocated from time to time, based on the supposed ease or difficulty with which they are fermented; unless one resorts to polysaccharides, however, striking differences are not apparent.

The glucose tolerance test may give valuable information in regard to sugar absorption. A typical blood sugar curve after the ingestion of 1.75 gram of glucose per kilogram of body weight is given in Figure 17. If absorption is impaired, the curve tends to become flatter. The blood sugar curve measures not only sugar absorption, but also its utilization by the tissues. When sugar utilization is defective (as in diabetes mellitus) the rise continues for several hours, reaching a higher peak and declining more slowly. A flat sugar curve, such as is obtained in celiac disease, may find its explanation: (1) in defective absorption and (2) in more rapid utilization.

The fats consumed by the infant, unlike those of the adult diet, are already emulsified. This aid in the process of digestion is, however, not a necessity, because the normal infant can emulsify fats himself. The digestion and absorption of fats, as in the adult, is quite complete. In pathological conditions the absorption of fat may be greatly impaired; the bulk of it may be excreted unchanged in the stools. The ability to absorb and utilize fat may be studied by metabolism experiments and by fat tolerance tests, in which the blood fat is followed at frequent intervals after the ingestion of a given quantity of fat.<sup>3</sup> Parsons has shown

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<sup>3</sup> The fasting blood fat level and the rise of the blood fat after fat ingestion are less constant phenomena than is the case with blood sugar.



that in conditions with impaired fat absorption (*e.g.*, celiac disease) a marked flattening of the blood fat curve is obtained.

**Intestinal Bacteria.**—The normal flora of the intestine play an important part in the processes of digestion and absorption, although it is an indirect one. Bacterial metabolic products may affect the reaction of the intestinal contents and thereby influence the splitting of foodstuffs and the absorption of minerals in particular. Probably no less important is the effect of bacteria upon the oxidation-reduction potential of the intestinal contents. Some of these organisms produce hydrogen; hence the intestine is usually a powerful reducing medium.

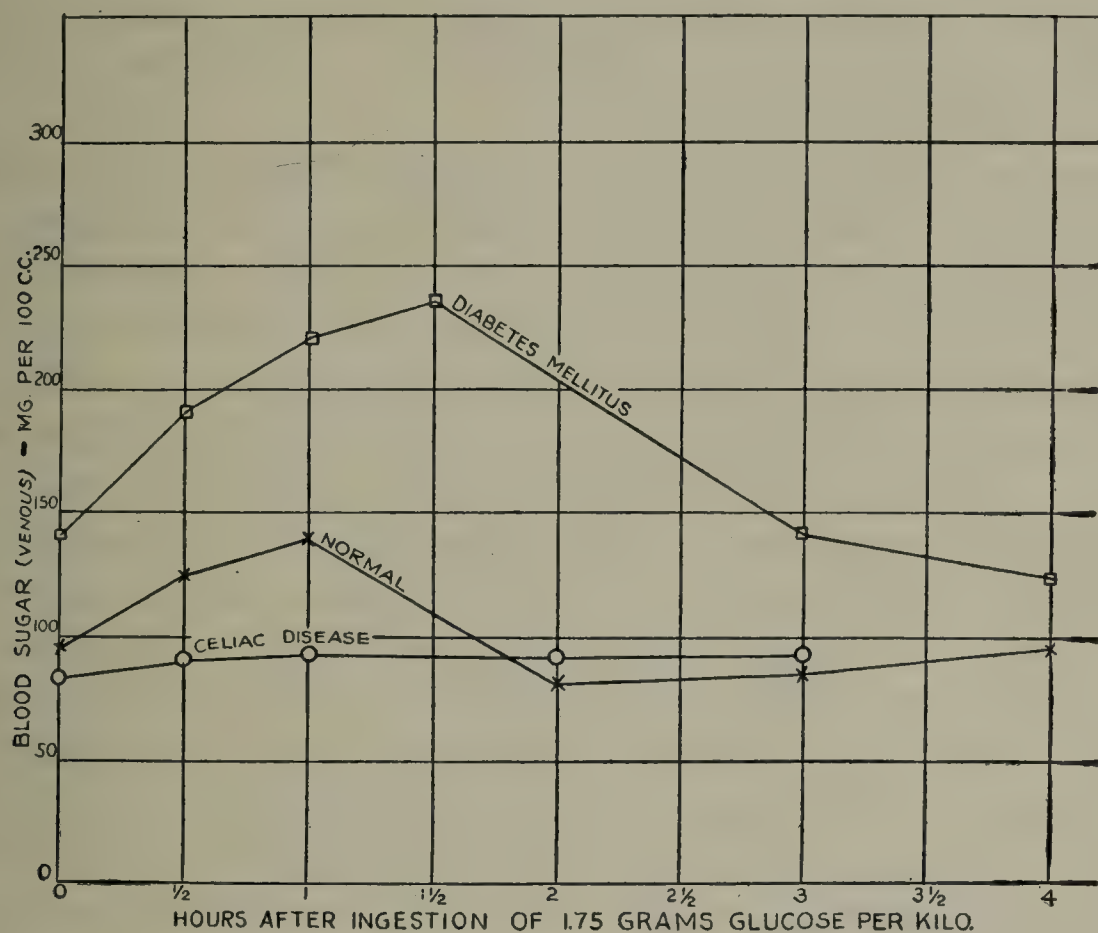


FIG. 17.—GLUCOSE TOLERANCE TESTS.

This last is not always the case, however, as is shown by the changes in pigment metabolism encountered in pathological conditions.

Bacteria are absent from the entire gastro-enteric tract at birth. They quickly enter by the mouth and rectum, and by the end of a few hours are usually found in all parts of the intestinal tract. The meconium bacteria are few in number and belong chiefly to the aciduric group (*B. bifidus* and *B. acidophilus*). After the ingestion of milk, bacteria are present in increasing number; *B. coli*, *B. lactis aerogenes* and *B. acidi lactici*, streptococci and staphylococci are constantly found. Other organisms frequently encountered are spore-bearers, particularly *B. welchii*, and nonlactose-fermenting organisms, such as *B. proteus*, *B. faecalis alkaligenes*, and *B. morgani*.

None of these organisms can be regarded as pathogenic. A great variety of opinion exists as to their importance and possible functions.

Bacteria are normally absent from the upper part of the small intestine; they become increasingly frequent in the lower portion, and are present in enormous numbers in the large intestine. In gastro-intestinal disorders, intestinal bacteria may be found in the stomach or duodenum; it is uncertain whether this results



from regurgitation or from suppression of the bactericidal gastric secretion. A change in the character of the food may produce distinct alterations in the bacterial flora; some organisms thrive upon carbohydrates, which they reduce to form lower fatty acids; others thrive on protein from which they may liberate toxic amines, indol, skatol, hydrogen sulphide and a variety of other substances. As a rule the carbohydrate fermenting bacteria are more abundant in the small intestine, while the proteolytic bacteria are more abundant in the large intestine.

**Feces.**—Although the importance of the stools as a guide to the feeding of infants has probably been overemphasized in the past, there is no doubt that valuable information can be obtained from this source as to the condition of the infant's digestion. A familiarity with the character of the stools under different conditions is essential to the pediatrician.

The first discharges after birth consist of meconium; this is composed of bile and intestinal secretions, with epithelial cells and hairs that have been swallowed *in utero*; it is of a dark brownish-green color, semisolid, and is usually passed from four to six times a day for the first two or three days. When the milk supply becomes well established, the appearance changes to that of normal milk feces. With lack of food, the stools may retain the character of meconium for a longer time. The amount of feces discharged daily by a healthy nursing infant is from one to two ounces (30 to 60 grams). Such stools may have the color of egg yolk but are usually paler and often green. They are seldom entirely smooth and homogeneous, but usually contain a large number of small, light yellow particles. The consistency is butter-like but often rather looser than this. Under normal conditions the stools are never watery. There is a slightly sour but not unpleasant odor. The reaction is acid, being usually between pH 5.5 and 6.5. This acidity is due largely to the presence of organic acids, but it is partly due to carbon dioxide. Owing to the escape of this gas, the reaction becomes less acid on standing. The number of stools passed by most breast-fed infants in the early weeks is from two to four daily. After the first month two stools is the average; many infants have one, others may have three or four.

The stools of an infant fed on cow's milk may differ little from the above. As a rule, however, they are firmer and more homogeneous. The number is seldom more than one or two a day, and there is not infrequently constipation. The color is likely to be paler, and the odor more unpleasant. The reaction is somewhat more alkaline, the pH being usually greater than 6.0; it may be on the alkaline side of neutrality.

The stool of the breast-fed infant contains 75 or 80 per cent water. Of the solids, fat constitutes about 40 per cent, half of this being in the form of soaps, about one-third fatty acids and the remainder neutral fat. Nitrogenous elements form about 20 per cent of the stool solids, and minerals (chiefly calcium and phosphorus) about 10 per cent.

The character of the stools is greatly modified by the diet. Foods which are not attacked by bacteria or digestive secretions appear unchanged in the stools. Protein curds in the stool are discussed below. Varying the proportions of protein and carbohydrate in the diet causes definite changes in the character of the stools. A high proportion of protein as compared to carbohydrate favors the growth of



putrefying bacteria. The stools are likely to be foul; they are alkaline in reaction; often there is constipation. When high protein is given in the form of calcium caseinate the excess of calcium combines with fat, and a considerable part of the stool consists of insoluble calcium soaps; the stools are dry and crumbly. This is essentially what is found in the condition known as *Milchnährschaden*. The addition of carbohydrate produces a rapid change in the picture. Fermentative bacteria become more abundant and their acid products (the volatile fatty acids) serve to check the growth of the putrefactive bacteria.

The addition or removal of fat from the diet causes surprisingly little change in the character of the stools. In some instances removal of fat from the diet causes loose, fermentative stools, for reasons which are not clear. Although a reduction of fat intake increases the percentage of fat absorption and a marked increase in the intake diminishes it, the percentage of the fat intake absorbed is fairly constant, more so than the actual fat absorption. A large amount of fat in the stools (steatorrhea) is rarely the result of an excessive fat intake. It may result in acute or chronic nutritional disorders in which the ability to digest fat is lost, in diarrheal conditions, or from congenital atresia of the bile ducts; the most extreme form of steatorrhea is seen in those rare cases in which there is atrophy of the acinar tissue of the pancreas.

The undigested masses appearing in the stools of infants taking milk are usually spoken of as "curds." These are of two varieties. When the stools are loose there are likely to be found small, soft, white or yellowish-white curds which consist almost entirely of neutral fat. They indicate that fat is being incompletely digested. A different type of curd is sometimes seen in children fed on raw milk. These are larger, smooth, hard masses about the size and consistency of lima beans. They are yellowish-brown in color, but are white or gray on section. They are present in small numbers in a stool, the rest of which may be entirely normal. These curds are composed of coagulated casein with an envelope of soap. The coagula are formed in the stomach, and owing to the coating of fat they pass through the intestine unchanged. Such curds are of no pathological significance; they disappear when the milk used is heated, acidified or treated with starch or alkali.

The *pigment* of stools has occasioned much interest. The normal pigment is derived from the bile. As secreted, it consists almost entirely of bilirubin. In the older child or adult this is rapidly reduced by the intestinal bacteria to the colorless urobilinogen (hydrobilirubin) and to its oxidation product the brown urobilin, from which the color of the normal stool is derived. The reduction of bilirubin is complete and is not reversible. The condition in infancy is somewhat different. At birth the intestine contains no reducing bacteria; the bile pigment of meconium is secreted unchanged. Although reducing bacteria are promptly acquired after birth, it appears that the reducing power of the infant's intestinal contents is distinctly less and is much more variable than that of the older child or adult. The reason for this is not altogether clear; it may be due to peculiarities of the bacterial flora upon a milk diet; it has also been attributed to air-swallowing, resulting in the presence of oxygen in the intestine. The fact remains that in the infant, although the bulk of the pigment in the stools is urobilin, a variable



amount of bilirubin is excreted as such; bilirubin crystals can sometimes be identified in the stools microscopically. Bilirubin is readily oxidized by the oxygen of the air to the green biliverdin. It is not an infrequent occurrence to see a stool which was yellow on being passed become green on standing, due to such oxidation. Bilirubin may be oxidized to biliverdin in the intestine when oxygen is present, and green stools may then be passed.

Absence or diminution of biliary secretion results in pale stools. Much of the pigment secreted in the bile is reabsorbed from the intestine. With constipation, owing to the greater length of time required for passage through the intestine, more of this pigment is reabsorbed; hence constipated stools are often pale in color. A pale stool does not necessarily mean that bile pigment is absent, however. Such a condition—particularly in older children—may result from the fact that nearly all the pigment exists as the colorless urobilinogen. Such stools will darken on standing and are thus easily distinguished from acholic stools. In diarrhea the opportunity for reabsorption of pigment is greatly diminished and large amounts may be lost by the body; this is also the case when mineral oil is given; bile pigment dissolves in the oil and cannot be recovered by the body.

Abnormal pigments may be found in the stool after ingestion of various vegetables. Black stools may result from bleeding high up in the intestine; they may occur after the administration of any heavy metal which forms a black sulphide; iron and bismuth are the commonest of these.

Streaks of blood due to small anal fissures may be associated with constipated stools. In dysentery, flecks of blood and mucus are found. Larger hemorrhages may occur with any type of ulcerative lesion of the intestine. In intussusception the stools contain blood and mucus without appreciable quantities of fecal matter.

The *microscopic examination of stools* gives little information that cannot be obtained on inspection. There may be found epithelial cells, mostly columnar, mucous aggregations, fat globules, and crystals of cholesterin, mucin, inorganic salts or bilirubin. Yeast fungi are frequently present and there are always enormous numbers of bacteria. The presence of an occasional leukocyte is of little significance. Large numbers of these and even frank pus may occur in dysentery or other inflammatory conditions of the bowel.

Much information of value can be obtained by the examination of infant's stools. An attack of diarrhea may indicate an enteric or parenteral infection, or a dietary indiscretion. The recognition of blood or of pathogenic organisms is of course a matter of the first importance. Since the character of stools may vary greatly in regard to color, consistency, volume, number a day, etc., one must be cautious in drawing conclusions from the stools alone. The general health and gain in weight are more reliable guides to the condition of the digestion.

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## CHAPTER XIII

### BREAST FEEDING

Maternal nursing is the natural and ideal method of infant feeding. Every mother should nurse her infant unless there are weighty reasons to the contrary. The large majority can do so. The physician should do all in his power to encourage maternal nursing and to insure its success.

Breast feeding possesses many advantages as compared with artificial feeding. The composition of woman's milk is ideally suited to the nutritional requirements and digestion of the infant. Although cow's milk may be so modified as to make it a suitable food for most infants, the possibilities for error, both in regulating the quantity and the composition are much greater. Breast milk is practically free from micro-organisms, whereas cow's milk contains large numbers. The chance for contamination with pathogenic bacteria is infinitely greater with artificial feeding. It is possible that breast milk contains valuable antibodies which are not present in cow's milk, but the evidence for this is scanty.

The mortality among infants artificially fed is very much greater than in nursing infants. This is particularly true among the poor and ignorant where artificial feeding is not likely to be well done. It is especially among this class that all possible efforts to encourage maternal nursing should be made. As a result of extensive propaganda, the number of mothers of all classes of society who nurse their children in the United States has greatly increased in recent years.

**When Maternal Nursing Should Not Be Attempted.**—(1) No mother who has or has had active tuberculosis in any form should nurse her infant: it exposes the infant to infection and can only lower the resistance of the mother to the disease. (2) Nursing should seldom be allowed when serious complications have been connected with parturition, such as severe hemorrhage, sepsis or puerperal convulsions; women may, however, recover from these conditions so as to be able to nurse successfully. Fatal convulsions have been reported in infants put to the breast two or three days after eclamptic convulsions in the mother. Although the dependence of these symptoms upon the mother's milk may be questioned, it would appear best to be conservative in permitting nursing after the severe grades of toxemia. (3) If the mother is suffering from any chronic disease or is very delicate, great harm may be done to her without corresponding benefit to the child. The response of individual mothers to nursing varies enormously; some find it a severe drain on their health while others appear to thrive on it. As a rule, mothers are more likely to succeed with first or second children than with later ones; the capacity for lactation tends to diminish with each successive pregnancy.

**Secretion of Breast Milk.**—The secretion of breast milk commences after parturition; only a few drops may be squeezed from the breasts before delivery. For the first few days the secretion is scanty; usually it becomes well established



by the third or fourth day, but it may be delayed until the tenth or twelfth day and yet come in abundance. One should not be too ready to decide that there will be no milk, but should persist in stimulating the breasts by suckling the child or by artificial means.

*Daily Quantity.*—The following figures give the average daily quantities for healthy breast-fed infants.

<i>Age</i>	<i>Approximate Quantity</i>
At the end of the first week.....	10 to 16 oz. (300 to 500 c.c.)
During the second week .....	13 to 18 oz. (400 to 550 c.c.)
During the third week .....	14 to 24 oz. (430 to 720 c.c.)
During the fourth week .....	16 to 26 oz. (500 to 800 c.c.)
From the fifth to the thirteenth week.....	20 to 34 oz. (600 to 1030 c.c.)
From the fourth to the sixth month.....	24 to 38 oz. (720 to 1150 c.c.)
From the sixth to the ninth month.....	30 to 40 oz. (900 to 1220 c.c.)

The amount of milk varies with the demands of the child in a very striking way. Complete emptying of the breast is the strongest stimulus to the production of milk; a hungry infant will therefore soon increase his milk supply. Conversely, when the supply is overabundant, as may happen when the milk first comes in, the breast is incompletely emptied and within a few days the quantity secreted falls off.<sup>1</sup> The more complete emptying of the breast by larger, more vigorous infants is well illustrated in Figure 18.

The quantity of milk obtained at one nursing shows a wider variation; it is greatly affected by the frequency of nursing. The following are average figures:

<i>Age</i>	<i>Approximate Quantity</i>
During the first week .....	5/8 to 1 1/2 oz. (18 to 45 c.c.)
During the second week .....	1 to 3 oz. (30 to 90 c.c.)
During the fourth week .....	1 1/2 to 4 1/2 oz. (45 to 140 c.c.)
During the sixth week .....	2 to 5 oz. (60 to 150 c.c.)
During the third month .....	2 1/2 to 5 1/2 oz. (75 to 160 c.c.)
During the fourth month .....	3 to 6 oz. (90 to 180 c.c.)
During the sixth month .....	4 to 7 oz. (120 to 220 c.c.)

The caloric value of breast milk is 20 calories per ounce. It is thus apparent that the average intake approximates very closely the energy requirements of the infant as determined by the calorimeter (100 to 120 calories per kilogram).

Observations made by Smith and Merritt on the rate of emptying of the breast are given in the accompanying charts (Figs. 18 and 19). The flow of milk is most rapid at the onset of nursing and decreases rapidly thereafter. Half of the quantity obtainable from one breast is taken in the first 2 or 3 minutes. After 8 minutes, few babies get any milk whatever. When both breasts are used at a nursing, the quantity obtained from each is smaller and the time required is somewhat shorter.

**Colostrum.**—The secretion of the early days of lactation, to which the name of “colostrum” has been given, differs quite markedly from the later milk. It is of a

<sup>1</sup> There are a number of instances in which the amount of milk secreted has been quite extraordinary—in some cases as much as four quarts a day. Lactation in exceptional instances is also unusually prolonged. We know of one well authenticated American case in which it continued for seven years. Among the Japanese it is frequent for it to continue up to three or four years. Among the Hottentots and other savage races, lactation may be prolonged until the sixth or seventh year.



deep yellow color, which is chiefly due to the presence of colostrum corpuscles. It has a specific gravity of 1.030 to 1.035, an alkaline reaction (average pH 7.7), and is readily coagulable by heat; sometimes the milk of the first day coagulates spontaneously. It contains more protein than does mature milk (the protein is from 3 to 5 per cent), a large part of which consists of globulin. It is also richer in minerals, particularly in sodium and potassium chloride. It contains less sugar and fat than does the later milk. Many of the fat globules are of unusual size, and there are present large numbers of granular bodies known as colostrum

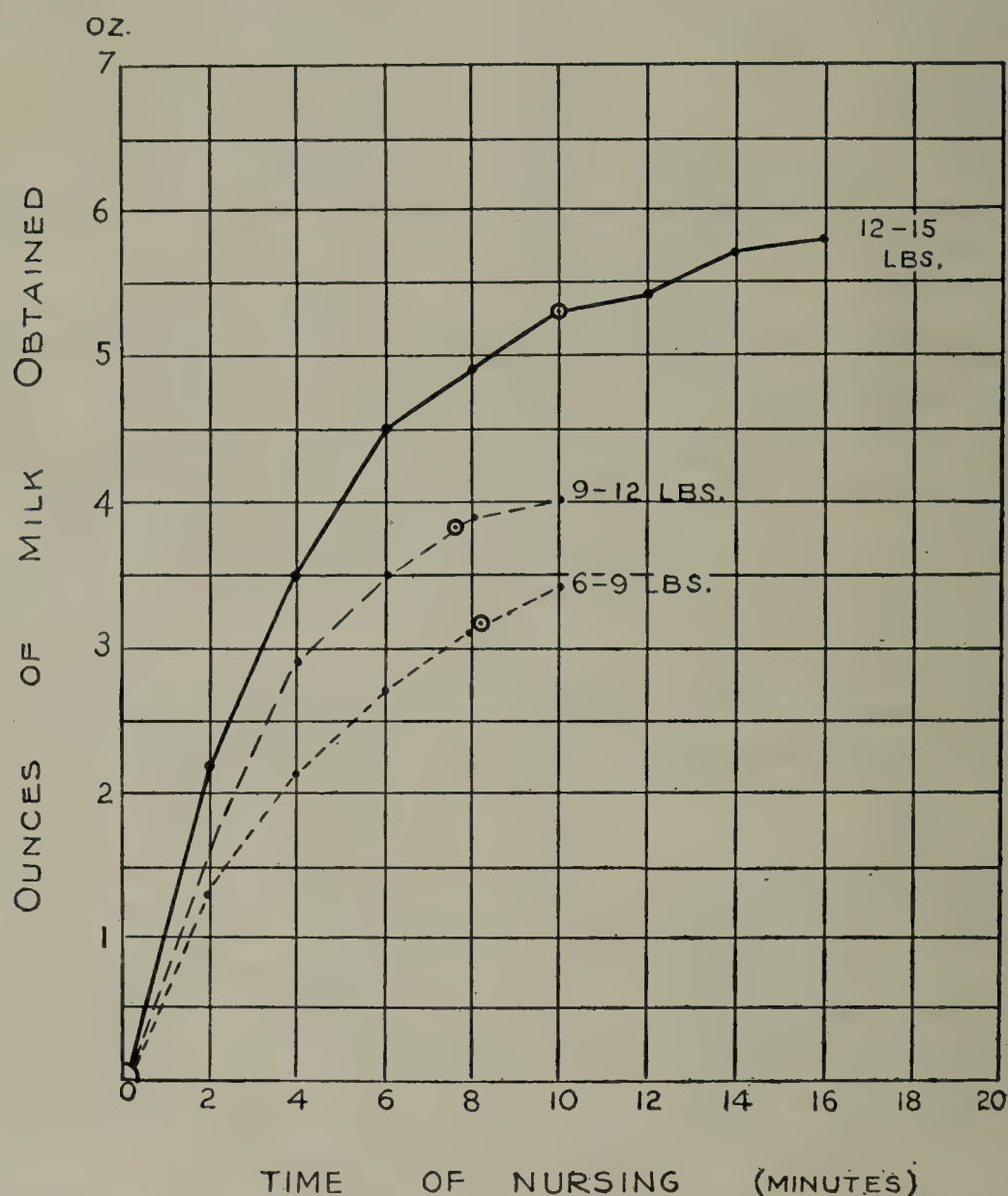


FIG. 18.—MILK OBTAINED BY INFANTS OF DIFFERENT WEIGHTS NURSING AT A SINGLE BREAST. (After Smith and Merritt, *Am. J. Dis. Child.* 1922, 24: 413.)

corpuscles. These are four or five times the size of the milk globules, and they are probably mononuclear phagocytes in which are contained numerous fat granules.

The characteristic features of colostrum milk continue for a period varying from five to ten days, but it is not until about the end of the first month that the milk assumes its stable or mature character. The milk of the intermediate period is sometimes spoken of as "transition milk." This change is characterized by a gradual decrease in the protein and minerals and a moderate rise in the sugar and fat. When the composition of mature milk is reached, little variation is then seen until near the close of lactation.

Theobald Smith has shown that the colostrum of the cow contains antibodies which protect the offspring against colon bacillus infections. No similar immune



substances are known to exist in human colostrum; this does, however, contain a high percentage of euglobulin, the fraction with which antibodies are frequently associated.

**Composition of Breast Milk.—Physical Characters.**—Mature milk, particularly the first portion of a nursing, is of a bluish-white color.<sup>2</sup> It is sweet to the

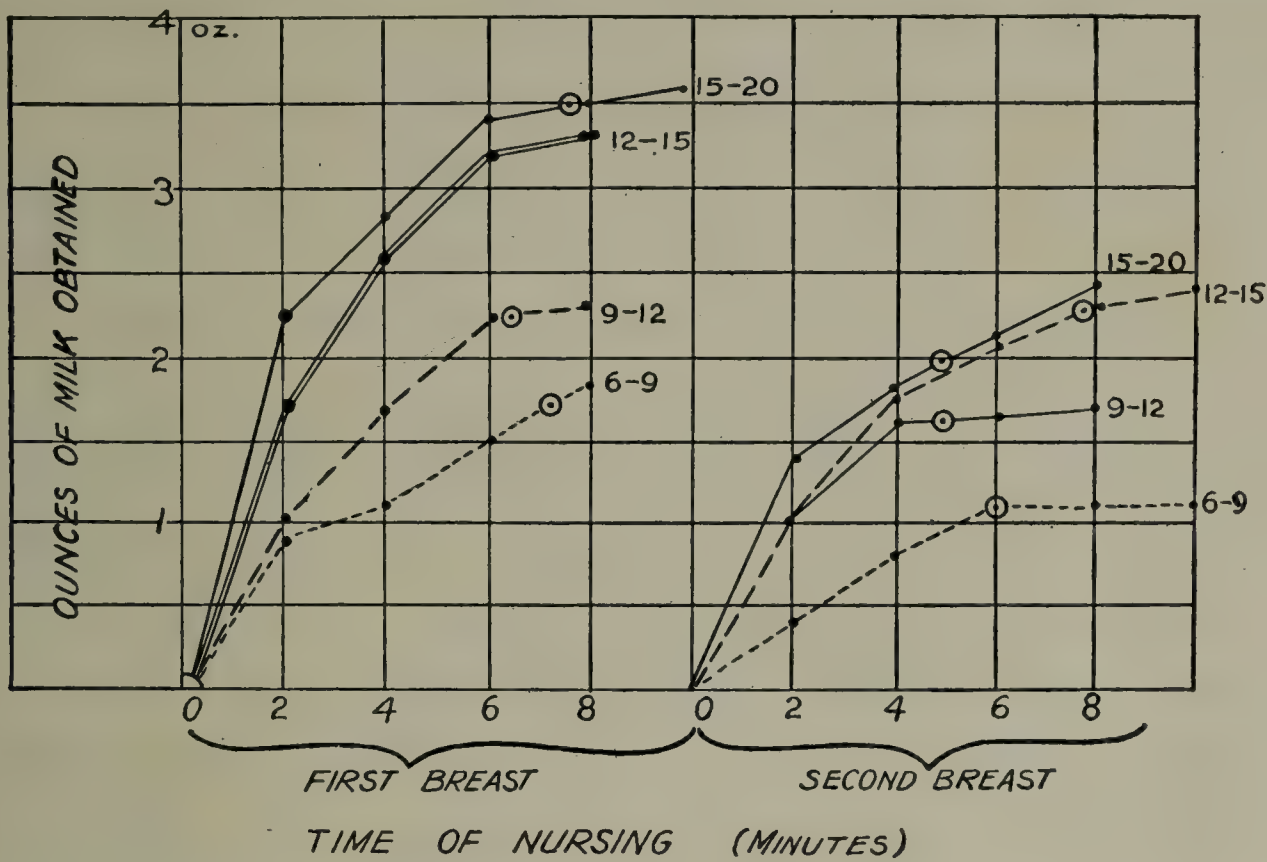


FIG. 19.—MILK OBTAINED BY INFANTS OF DIFFERENT WEIGHTS NURSING TEN MINUTES AT EACH BREAST.  
(After Smith and Merritt, *Am. J. Dis. Child.* 1922, 24: 413.)

taste; its reaction when fresh varies from pH 6.8 to 7.4, averaging close to 7.0. The specific gravity varies between 1.026 and 1.036, the average being 1.031. Microscopically there are seen great numbers of fat globules of variable size, with some granular matter and occasional epithelial cells.

**Chemical Composition.**—The following table gives the average composition and common healthy variations of mature milk:

TABLE XIV  
CHEMICAL COMPOSITION OF THE AVERAGE AND OF COMMON HEALTHY VARIATIONS OF MATURE MILK

	Normal Average	Common Healthy Variations
Protein .....	1.25	1.00 to 2.00
Sugar .....	7.50	6.50 to 8.00
Fat .....	3.50	3.00 to 5.00
Ash .....	0.20	0.18 to 0.25
Water .....	87.55	89.32 to 84.75
TOTAL .....	100.00	100.00 100.00

<sup>2</sup> In appearance colostrum is quite similar to cow's milk. The change to the bluish watery appearance of mature human milk, which more closely resembles skimmed cow's milk, is often interpreted by ignorant or uninformed mothers as evidence that the milk is deteriorating in quality. This is a frequent cause of unnecessary weaning.



PROTEIN.—The total protein of mature milk is usually between 1.0 and 1.5 per cent. In abnormal specimens it may vary from 0.7 to 3.5 per cent. The protein is highest in the colostrum period; after the first month it is relatively constant, but tends to fall toward the end of lactation. The early part of the nursing has a somewhat higher protein content.

The important proteins are casein and lactalbumin; small amounts of globulin are also present. The lactalbumin constitutes almost two-thirds of the protein, in marked contrast to cow's milk in which most of the protein is casein. From the nutritional point of view, lactalbumin is a more valuable protein. Casein possesses the peculiar property of being coagulated by acid<sup>3</sup> or by the enzyme rennin. The differences in the curds of breast milk and cow's milk are due chiefly to the greater quantity of casein in the latter, but also partly to the relatively greater amount of fat enmeshed in the breast milk curd.

FATS.—This exists as a fine emulsion of particles varying from 0.9 to 22  $\mu$  in diameter (Engel). The fat of woman's milk consists almost entirely of the neutral fats, palmitin, stearin and olein, the last mentioned predominating; small quantities of free fatty acids and of unsaponifiable material are present. The fat of woman's milk is relatively low in glycerides of the short-chain volatile fatty acids, as compared with that of cow's milk. Engel has shown that marked variations in the composition of the milk fat occur, depending upon the type of fat eaten by the mother.

The quantity of fat shows a greater variation than that of any of the other constituents. The average is about 3.5 per cent, but variations from 2.0 to 6.0 per cent are not uncommon; the highest percentage we have known was 10.9. The proportion of fat is much influenced by the time in the nursing when the specimen is taken. The first milk drawn may contain only 1 per cent fat, while at the end of nursing it may contain 7 or 8 per cent. No analysis is of value unless the specimen

<sup>3</sup> The best interpretation of the phenomenon of *coagulation by acid* appears to be as follows: The reaction of milk (pH 6.7) is well on the alkaline side of the iso-electric point of casein (pH 4.7); casein exists therefore as caseinate. Some of this at least is in true solution, part may be in the form of a colloidal suspension. Iso-electric casein is highly insoluble; as acid is added to milk and the reaction approaches the iso-electric point, the solubility decreases approaching that of iso-electric casein; eventually the casein can no longer be held in suspension and a visible coagulum forms. When exactly the correct amount of acid is added and conditions are such as to insure thorough mixing, the curd consists of pure iso-electric casein. Such conditions are rarely attained in practice. Casein tends to precipitate before the iso-electric point is reached; the coagulum then contains a variable amount of caseinate. The process of coagulation is reversible; the curd may be redissolved by the addition of sufficient alkali, and re-formed by subsequent acidification.

*Coagulation by rennin* is not identical with the foregoing. Rennin converts casein into the protein paracasein, which possesses different physicochemical properties. Paracaseinates are less soluble than caseinates; a coagulum therefore forms promptly although no change in pH has occurred. The process of coagulation is not reversible in this case. The curd contains much mineral matter.

*Calcium salts* favor coagulation, and the addition of substances which bind calcium (citrates, oxalates, etc.) tends to inhibit curd formation. Although various explanations of this phenomenon have been given (such as neutralization of the cataphoretic charge of the colloidal casein particles by a bivalent ion), it seems likely that the effect of calcium may be due to the relative insolubility of the calcium caseinates and paracaseinates. Robertson and others have shown that at the body temperature calcium caseinate is less soluble than the caseinates of the alkali metals; comparative studies on the solubility of the paracaseinates are not available.

Regarding *the effect of heat on coagulation*, it is known that boiled milk is coagulated more readily by rennin than is unheated milk, and that heating alters the character of the curd subsequently formed by acid or by rennin. A number of changes are brought about by heating milk and it is not clear which of these is responsible for the altered curd formation. The calcium phosphate complex may be altered by heat, and crystalline  $\text{CaHPO}_4$  may be deposited. Lactalbumin is coagulated by temperatures above 62° C., and this may affect the physical state of the casein. Although casein itself is not noticeably "denatured" and its antigenic properties are unaffected by heating, it has been shown that it does suffer some chemical change; the base-combining power is definitely altered.

(Robertson, *The Physical Chemistry of the Proteins*. Longmans, New York, 1918; Pertzoff, *J. Gen. Physiol.*, 1927, 10: 961, 987; 1928, 11: 239.)



comprises practically the whole of the nursing. The following figures illustrate typical variations in composition seen with different portions of a single nursing:

TABLE XV  
TYPICAL VARIATIONS IN PERCENTAGE COMPOSITION OF DIFFERENT PORTIONS OF A SINGLE NURSING

	1st Portion	2nd Portion	3rd Portion
Protein .....	1.13	0.94	0.71
Fat .....	1.71	2.77	5.51

SUGAR.—The lactose is in solution. It is more nearly constant than the other ingredients, the usual limits being between 6.5 and 8.0 per cent.

MINERALS.—The following figures for the mineral constituents of woman's milk were obtained by Holt, Courtney and Fales. Figures are given in per cent of whole milk.

TABLE XVI  
MINERAL CONSTITUENTS OF WOMAN'S MILK

Period	Total Ash	Na	K	Ca	Mg	Cl	P
Colostrum (1-12 days) ....	.308	.034	.078	.033	.006	.057	.018
Transition (12-30 days)...	.241	.019	.059	.029	.003	.058	.018
Early mature (1-4 mos.)...	.206	.011	.045	.035	.005	.035	.015
Late mature (4-9 mos.)....	.207	.010	.051	.033	.005	.036	.015
Late milk (10-20 mos.)....	.198	.010	.048	.028	.004	.044	.013

The sulphur content is approximately 0.0016 per cent; most of which is in the form of cystine and should not properly be classed as one of the mineral constituents. All of the minerals are present in ample quantities with the exception of iron, which is present in a concentration of 1.5 to 2.0 milligrams per liter.

The difference in the mineral content of cow's and woman's milk will be considered later.

BUFFER VALUE.—The buffer content of breast milk is comparatively low; the significance of this fact in digestion is considered elsewhere (p. 120).

ENZYMES.—Lipase, amylase and other enzymes have been demonstrated in breast milk. Their importance is questionable.

VITAMINS.—All the known vitamins are present in breast milk, the quantity being greatly influenced by the intake of the mother. Vitamin deficiencies seldom occur in breast-fed infants in this country, except in the case of vitamin D. Rickets is not infrequently seen in nursing infants, particularly in the colored race.

**Examination of Milk.**—The chemical examination of milk is seldom of any assistance. Symptoms of indigestion—chiefly gastric—can sometimes be attributed to an unusually high percentage of fat. By shortening the nursing time and employing both breasts at a feeding, the fat content may be reduced, usually with prompt symptomatic relief. It is, however, a good general rule that if the milk is present in sufficient quantity, the quality, too, is adequate. The quantity of milk is



best determined by weighing the child before and after nursing; sensitive scales should be used. Since the amount secreted varies somewhat at different times of the day, one should be cautious in drawing conclusions unless the secretion has been observed for at least a twenty-four-hour period. Weighing should be done without removing the diaper in order to avoid the loss of weight due to passage of the excreta.

**Conditions Affecting the Composition of Breast Milk.**—*Age of the Nurse.*—This has little influence; the milk of elderly women may be slightly lower in fat.

*Number of Pregnancies.*—The fat and protein content are as a rule slightly higher in primiparae, while the sugar is slightly less.

*Acute Illness.*—In minor ailments the milk may be somewhat reduced in quantity. In some illnesses the fat is often low and the protein high. Bacteria may be present in the milk in septic conditions.

*Menstruation.*—The effect of this is exceedingly variable, depending upon the individual and the ease of menstruation. The most frequent changes are a diminution of the fat and an increase in the protein. Minor digestive disturbances occur in a small percentage of infants. The return of menstruation is not an indication for weaning.

*Diet.*—If the mother is receiving an inadequate amount of food, the milk is likely to be poor both in fat and in protein. If she is receiving too little fluid, the milk is diminished in quantity. Under conditions of normal nutrition, diet has little influence on the composition of the milk, with the exception of vitamins, which do not appear to be synthesized in the body, and the character of the fat which is much influenced by the fat of the diet.

The nursing mother requires considerably more food than the average adult; not only must the calories secreted in the milk (400 to 1200 a day) be supplied, but in addition a certain amount of energy is probably consumed in the process of secretion itself. The water intake must be increased in order to take care of the additional fluid secreted.

Cow's milk is not to be considered a specific lactagogue, but it is a valuable and convenient food for the nursing mother. It is a good general rule to give a daily quantity of cow's milk similar to that of the breast milk which is being secreted. The milk need not be given as such; if it is distasteful it may easily be concealed in the cooking. The importance of milk is that it provides a liberal amount of minerals, notably of calcium; a deficiency of this element in the diet is likely to cause decalcification of the teeth. The old saying "for every child a tooth" has a definite basis in fact. The nursing woman should have a generous diet of simple food. Rich and highly seasoned dishes should be avoided, not so much because they upset the child as because they are likely to disturb the digestion of the nurse. One should not make the error of overfeeding, which may result in indigestion, or merely in fattening the nurse.

*Stimulants.*—The use of tobacco, tea and coffee in moderation is not harmful. Excesses should, however, be avoided. Alcohol taken in small amounts does not appear in the milk. The general use of alcohol by nursing women is, however, to be condemned. An alcoholic debauch may produce severe toxic symptoms in the infant.



*Drugs.*—A number of drugs may be eliminated in the milk, particularly when full doses are given or after prolonged administration. Atropine, many of the opium derivatives, mercury, lead,<sup>4</sup> arsenicals, salicylates, iodides, bromides, and some of the alkaloid cathartics have all been found in the milk, sometimes in sufficient quantities to produce symptoms in the nursing child.

*Pregnancy.*—The milk of a nursing woman who has become pregnant is generally scanty and poor in fat. The milk of a woman suffering with toxemia of pregnancy may be toxic to the infant.

*Bacteria.*—Occasional organisms may be found in normal breast milk; they are chiefly cocci derived from the external milk ducts and are of no importance. In the presence of mastitis, pathogenic bacteria may be found. In septicemia, pathogenic organisms may reach the milk even in the absence of mastitis.

*Immune Bodies.*—Animal experiments have demonstrated that diphtheria anti-toxin is regularly secreted in the milk. The Widal reaction has been obtained with the milk of nursing mothers and also with the blood of their healthy infants. It is probable that other instances exist in which antibodies are conveyed to the infant through the milk. Such a mechanism will not, however, explain many of the phenomena of immunity in the newly born infant. This question is discussed elsewhere.

*Allergens.*—Allergic phenomena may appear in the nursing infant, presumably as a result of minute quantities of foreign protein transmitted through the milk.<sup>5</sup> As a rule, the mother is herself insensitive to the offending substance. Such instances are, however, distinctly rare.

*Nervous Impressions.*—The effect of the nervous condition upon the secretion of milk is very striking, and much more important than that of the diet. Both the quantity and the quality may be markedly affected. Fright, grief, passion, excessive sexual indulgence, or any great excitement may entirely arrest the secretion or may so alter it as to make the child acutely ill.<sup>6</sup> Worry, anxiety, fatigue or any prolonged nervous strain may produce these effects. It is the nervous condition of the mother more than anything else which determines her success or failure as a nurse. A mother who would nurse successfully, must have plenty of rest and sleep, moderate exercise, and lead a regular, natural life.

**Care of the Breasts during Lactation.**—The most scrupulous care should be given to the cleanliness of the breasts, particularly of the nipples; they should be

<sup>4</sup> We have seen two instances of lead encephalitis in which the lead was acquired through the milk. In one case a lead acetate ointment was applied to the breast, but was wiped off before nursing. The other case resulted from the use of lead nipple shields; the excretion of lead continued in the milk more than a week after the shields had been discarded.

<sup>5</sup> Lyon reported the case of a nursing infant who developed severe angioneurotic edema at the age of three weeks. Positive skin reactions were obtained to white navy beans and to sweet corn, both of which the mother had been eating. The infant gave a positive skin reaction to the mother's milk. The mother was herself insensitive to these substances. The angioneurotic edema was made to disappear by eliminating these articles from the mother's diet; it recurred when navy beans were again eaten. (*Am. J. Dis. Child.*, 1928, 36: 1012.)

<sup>6</sup> The following case quoted by Hartley (*Essay on Milk*, New York, 1842, p. 97) is related by von Ammon, physician to the king of Saxony. "A carpenter quarreled with a soldier billeted in his house, and was set upon by the latter with his drawn sword. The wife of the carpenter at first trembled from fear and terror, and then suddenly threw herself furiously between the combatants, wrested the sword from the soldier's hand, broke it in pieces, and threw it away. During the tumult, some neighbors came in and separated the men. While in this state of strong excitement, the mother took up her child from the cradle, where it lay playing and in most perfect health, never having had a moment's illness; she gave it the breast, and in so doing sealed its fate. In a few minutes the infant left off, became restless, panted and sank dead on its mother's bosom."



washed carefully before and after nursing with plain water or a solution of boric acid. A clean piece of gauze should cover the breasts between nursings; tight compression by the clothing should be avoided. If the nipples tend to become chafed, plain or boric acid ointment may be applied. With tender nipples, the use of a glass nipple shield may be advantageous; lead nipple shields should not be employed.

The chief danger lies in fissured nipples which may result in infection of the breast and possibly of the child also. Nursing should not be permitted under these circumstances, for it tends to aggravate the condition. Healing of the nipples may be promoted by applications of silver nitrate or by some bland ointment. The breast should be emptied by manual expression or by a breast pump. The milk may be fed to the infant unless evidences of infection of the breast are present.

Engorgement (caking) of the breasts may occur when the milk supply is overabundant. This sometimes occurs when the milk first comes in; it may happen when the child's appetite fails, due to acute illness or some other cause. The practice of applying tight binders to the breast to decrease the milk supply is a relic of barbarism. Careful observations have shown that this does not hasten the diminution of the milk supply; it adds greatly to the discomfort of the mother. Within a day or two the supply of milk tends to adjust itself to the decreased demand, even if no measures are used; a moderate restriction of fluids may, however, be of some benefit.

**Nursing during the First Days of Life.**—This is necessary, to accustom the child and the mother to the procedure, and to stimulate the secretion of milk; it probably also promotes uterine contractions. Beginning twelve hours or so after delivery, the child should be put to the breast on the first day once every six hours and on the second day once every four hours. The child seldom gets more than four to six ounces a day for the first two days. Exceptionally large or vigorous infants who cry vigorously may require additional fluid or food. A little water or a 5 per cent sugar solution may be first given; two to four teaspoonfuls at a time are sufficient. If this does not satisfy the child, supplementary bottle feeding may be begun on the second day. Should the milk be delayed beyond this time, a supplementary feeding should always be given; the child should be put to the breast at regular intervals, but only for two or three minutes; a bottle is then offered.

There is some disadvantage in early bottle feeding, since the infant quickly learns that it is easier to get food from the bottle than from the breast; his efforts at the latter may soon become only half-hearted. It is important not to cease efforts to induce milk secretion for several days longer. Should the child's sucking prove ineffectual, manual expression or a breast pump should be resorted to.

**Nursing Habits.**—Regularity in nursing is of great importance; it may make the difference between successful and unsuccessful nursing. After the third day, six nursings in the twenty-four hours should be given. An infant at this age can usually be depended upon to take at least one long sleep of from four to six hours in the twenty-four. For the rest of the day the child should be awakened, if necessary, at the regular nursing time and put to the breast, this plan being continued until ten o'clock at night. He should then be allowed to sleep as long as he will, and but one nursing given between this hour and six in the morning. In the course of



two or three weeks a healthy infant can usually be trained to nurse and sleep with almost perfect regularity, frequently going eight hours regularly at night without feeding. Some young infants are unable to obtain sufficient milk at one nursing to enable them to go four hours without symptoms of hunger; they cry continually for an hour preceding nursings. When this is the case, the interval may be shortened to three hours. This practice should not be continued beyond the third month. If at the end of this time the child cannot be placed upon a four-hour schedule, supplementary <sup>7</sup> feeding should be given. Nursing with long intervals and relieving the mother of night nursing as soon as possible are of the greatest value, and will often enable her to continue lactation when it would otherwise be terminated. The child should not be permitted to sleep in the same bed with the mother; the temptation to frequent night nursing is thus removed.

If the supply of milk is abundant, one breast only should be used at a nursing; the less frequent use of each breast decreases the likelihood of difficulties with sore or cracked nipples. When the supply of milk is scanty, both breasts should be used; the more frequent stimulus is of assistance in increasing the milk supply. The duration of nursing should not be more than ten minutes if one breast is used, nor more than six minutes on each breast when both are used at a nursing (see page 130). Except in the case of feeble infants who nurse more slowly, a longer period is of no value, and is an added burden to the mother.

After nursing, the infant should be held over the mother's shoulder for a few moments and patted gently to aid the expulsion of such air as may have been swallowed. He should then be returned to his crib and not disturbed for some time.

**Symptoms of Unsuccessful Nursing.**—One should not hastily wean a child on account of symptoms which may have nothing to do with the food, nor should one wean when the causes of indigestion are remediable. On the other hand, nursing should not be continued simply because a conscientious mother desires it, when every indication points to failure.

A parenteral infection will produce digestive disturbances in a breast-fed infant identical with those produced in the artificially fed infant. All too frequently these are blamed upon the milk supply and the infant is unnecessarily weaned. Organic causes of digestive symptoms should always be thought of; the vomiting of pyloric stenosis is not infrequently attributed to the milk.

**Underfeeding.**—The symptoms of underfeeding are readily confused with those of indigestion. There is failure to gain or even loss of weight. There may be constipation with flatulence and colicky pain; at other times the stools may be thin, greenish and numerous,<sup>8</sup> but small. There is usually fretfulness; at times vomiting may occur. Fever is notably absent. The symptoms of underfeeding result in part from the restlessness due to hunger, in part from air which is swallowed during the ineffectual and often prolonged attempts to get sufficient nourishment from the breasts. There is nothing characteristic about these symptoms. A diagnosis of underfeeding can be made only by determining the quantity of milk taken. Something may be learned from the manner in which the child takes the breast. When

<sup>7</sup> A bottle feeding which immediately follows a nursing is sometimes designated as "complemental," one which replaces an entire nursing being described as "supplemental" or "supplementary." We shall use the latter term in both senses.

<sup>8</sup> This is sometimes referred to as "starvation diarrhea."



the milk is abundant, the infant will seldom nurse more than five or six minutes, sometimes less. If the milk is very scanty he will frequently nurse half an hour or more and then stop, more because he is exhausted than because he is satisfied. Sometimes when the breasts are practically empty the child will seize the nipple and nurse vigorously for a few moments, then drop it and refuse to make any further efforts. The only satisfactory way of determining the quantity of milk secreted is to weigh the child before and after nursing. This should be done at each nursing until all doubt is removed. A scanty milk supply usually means a milk of poor quality—low in fat; while an ample milk supply is a good indication that the quality is satisfactory.

In the presence of a scanty milk supply, one is often able to overcome the difficulties and continue nursing to advantage. Until a decided increase in the milk has occurred, the child should have, after taking both breasts, a supplementary bottle feeding sufficient in amount to insure his being properly nourished. In this way the stimulating effect of suckling upon the secretion of milk is secured. The child's efforts may be reënforced by manual expression<sup>9</sup> or by an electric breast pump such as that devised by Abt. The old-fashioned breast pump with a rubber bulb develops a relatively small negative pressure and is not likely to be of much help. The hygiene of the mother should be given careful attention. She should be given an undisturbed rest at night; if possible, she should be relieved of the care of the infant at this time, and if feeding is necessary, a bottle should be given. She should have a certain amount of fresh air and exercise each day. Worry and other causes of nervous anxiety or emotional strain should be removed. One should make sure that the diet and fluid intake are adequate. It sometimes happens that a mother whose milk supply is inadequate while in the hospital responds with an abundant flow of milk after returning home.

In the large majority of instances it is possible by these measures to secure an adequate milk supply, but not in all. If after two or three weeks' trial the mother is unable to furnish more than 10 ounces of milk a day, weaning should be undertaken.

**Overfeeding.**—This is less of a problem than underfeeding. When the milk first comes in, the supply may be excessive. An overabundant milk supply on the part of a wet nurse may lead to overfeeding. The symptoms produced are usually gastric, regurgitation or perhaps vomiting; more rarely there is intestinal disturbance with overactivity of the bowels, and possibly colic. Within forty-eight hours or so the supply adjusts itself to the demand; in the meantime the intake may be reduced by shortening the nursing time.

Similar symptoms are occasionally observed with a milk rich in fat; this not infrequently occurs in primiparae between twenty and thirty years of age. Something may perhaps be accomplished by a reduction of the diet or by additional

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<sup>9</sup> The technic of manual expression is important. Simple massage or squeezing of the breast accomplishes little. The thumb and forefinger, separated as far as the width of the areola, should be pressed straight back, compressing the breast against the thorax. They are then brought together forcibly behind the nipple, and drawn forward with a rather rapid motion. The fingers should not be allowed to slip over the skin. This cycle should be repeated 15 or 20 times a minute until no more milk is obtained. The milk may be collected in a sterile glass or other container. With skill and practice the breast may be emptied as completely as it is done by the average robust infant. Finkelstein reported the maintenance of a supply of 30 to 40 ounces a day for several months in a mother whose nipples were so retracted that nursing was impossible.



exercise on the part of the mother. Another method is to dilute the milk by giving water from a bottle before nursing. Since the fat increases with the duration of the nursing time, it is advantageous to employ both breasts at each nursing and to shorten the nursing time; very often this measure alone will cause the symptoms to disappear.

Instances in which the breast milk is unsuitable for digestion are extremely rare, but do nevertheless exist. One should bear in mind that foreign proteins may at times enter the milk and produce allergic phenomena in the child. If the mother has been eating garlic, a substance with an unpleasant taste is secreted in the milk. There are doubtless other instances in which peculiarities of the mother's diet may alter the character of the milk.

**Diarrhea.**—As in the case of artificially fed infants, digestive disturbances, particularly diarrhea, result from the presence of parenteral infections. Diarrhea *per se* is not a cause for weaning. If the disturbance is a mild one it may be met by shortening the nursing time, thereby reducing the food. In other cases it is advantageous to alternate the breast feedings with a feeding such as protein milk, buttermilk or boiled whole milk with cereal water. The mother's milk supply should be maintained during this period by artificial means. When the symptoms have been overcome, these feedings may be replaced by nursings.

The treatment of other digestive disorders that may occur in nursing infants: vomiting, colic, constipation, severe diarrhea and dehydration, etc., will be taken up subsequently, since it is much the same as for artificially fed infants.

**Wet Nursing.**—When maternal nursing is impossible or undesirable, the milk of another woman would seem to be the most natural and best substitute. While this is theoretically true, the practical obstacles are so many as to put wet nursing out of the question as a general method of feeding. In America the class which furnishes most of our wet-nurses has steadily diminished. The expense, the danger of transmitting contagious disease and the difficulty of obtaining proper care for her own infant, are all very serious objections to a wet-nurse.

While artificial feeding can be satisfactorily accomplished in the large majority of instances, there are conditions in which breast milk offers a real advantage. This class comprises premature and very delicate small infants, and a certain number who have developed extreme degrees of inanition; with such the chances of success are somewhat increased if breast milk is available. In a few cities well-supervised breast milk dairies have been established; the expense of such milk is, however, great. When such a supply is not available, or when its expense is prohibitive, wet nursing remains the only recourse, if a supply of breast milk is to be obtained.

In the selection of a wet-nurse, the age of her child is not essential, for after the first three weeks the changes in the composition of the milk are insignificant. It is always desirable that the wet-nurse shall have nursed her own infant long enough to demonstrate that she has an adequate milk supply.

A good nurse must, first of all, be a healthy woman. One with a history of active tuberculosis in any form should be excluded. A careful physical examination of the mother and her child and a Wassermann reaction with the mother's blood should always be insisted upon. Preferably a wet-nurse should have a phlegmatic



temperament and should be between twenty and thirty years of age, but these requirements are not essential. The condition of her child is the best evidence of the quality and quantity of the milk; the infant should always be seen before the nurse is accepted. It sometimes happens that the change to new surroundings is accompanied by a marked decrease in the milk supply. One should not be too hasty in discarding a nurse on this account; as a rule, under proper treatment the regular flow of milk is soon reëstablished.

It is not essential that an infant be put to the breast; the milk may be expressed and fed to the infant separately. In general, however, it is desirable, if the infant is strong enough, to have him nurse at the breast. The chance of contamination of the milk is thereby eliminated.

There is no objection to the use of a colored wet-nurse for white infants; a deficiency of vitamin D in the milk is, however, more common in the colored.

**Addition of Other Foods.**—If an infant can be given sun baths or ultra-violet radiation in some other form, the addition of vitamin D is unnecessary. Otherwise, cod liver oil or irradiated ergosterol should be given after the first month. Scurvy is seldom seen in breast-fed infants. Although the citrus fruit juices, particularly orange juice, may be given earlier and are sometimes valuable laxatives, it is unnecessary to begin them before the seventh month. The addition of other foods to the diet will depend somewhat upon the supply of breast milk, but in any case they should be started by the seventh or eighth month. Vegetable purées, cereals, scraped meats, beef, liver and egg may then be added to the diet, one article at a time. Toast, crackers and other foods requiring mastication must be postponed until the teeth are sufficiently numerous.

\* Start at  
about 5th  
month

**Weaning.**—Weaning should be done gradually, if possible; sudden weaning causes discomfort to the mother and may be followed by indigestion in the infant, especially if an inappropriate food is substituted. Weaning in hot weather is usually to be avoided, but the harm from this is not nearly so great as when lactation is unduly prolonged because of a prejudice against a change of food at this time. While there are many women of the lower classes who are able to nurse their children to advantage for the entire first year, the number of such among the upper classes is small. By the latter, nursing can rarely be continued beyond the eighth, and sometimes not beyond the fifth month, without unduly draining the vitality of the mother and at the same time harming the child. Since the early months of breast feeding are the most important, every effort should be made to have the mother continue nursing for four or five months. There is seldom trouble in feeding a baby for the second half year who has done well upon the breast for the first half.

It is a common mistake to continue nursing too long owing to a dislike of making a change when things are going reasonably well. The child's weight often gives valuable information as to the need of supplementing the diet or weaning completely before the usual time. In the absence of evident signs of disease, a stationary weight for several weeks makes weaning advisable; a steady loss makes it imperative.

When a nursing infant has been accustomed from birth to take one bottle feeding a day—always a great convenience to the mother—gradual weaning is



generally an easy matter; otherwise it is sometimes an impossibility, the child refusing all food except the breast as long as this is given, and nothing but starvation inducing him to take food either from a bottle or a spoon.

Sudden weaning may be required at any time from the development of serious acute disease in the mother, such as typhoid fever, pneumonia, or grave chronic disease such as tuberculosis or nephritis, from the intercurrent of pregnancy or from disease of the breast. Through many of the minor ailments mothers frequently nurse their children without seeming detriment to either. In some acute illnesses of short duration, it is better unless weaning is decided upon, to feed the child from a bottle and maintain the flow of milk by manual expression or a breast pump. The previous flow can often be reestablished after a lapse of two weeks; sometimes after a much longer time.

In cases of sudden weaning it is advisable to use a more dilute milk mixture than would otherwise be given. After the first day or so, when the infant has become accustomed to cow's milk, the strength of the feeding may be rapidly increased.

The difficulties in weaning a child of nine or ten months who has had nothing but the breast, are sometimes great. To try to teach older infants to take a bottle is unwise, feeding from a cup or spoon is usually quite as easy. Continued coaxing or forcing of food only prolongs the struggle. Starvation is by far the most effective method. Food should be offered at regular intervals and taken away at once, if refused. A variety of things may be offered—cow's milk, cereals, broths, bread and milk, etc.; the nature of the food makes little difference. A strong-willed child will often hold out for twenty-four or thirty-six hours; occasionally for forty-eight hours. The pangs of hunger are then so acute that he capitulates. Serious symptoms from withholding food under such circumstances we have never seen. Water should, however, be given. The development of a mild ketonuria need occasion no concern.

**Mixed Feeding.**—By mixed feeding is meant a combination of artificial feeding and nursing. Mixed feeding may be employed whenever the mother's milk supply is insufficient. There is a great advantage in supplying part of the food in the form of breast milk when it is not possible to give it all in this form.

If the mother's health begins to fail, or if nursing appears to be an undue strain, she may be relieved of night nursing or one or more nursings during the day, and the bottle substituted. In this way she may be enabled to continue lactation for some time longer than would otherwise be the case. Mixed feeding is often necessary during the early weeks before the mother's milk supply becomes well established. Under these circumstances, it is better not to alternate the breast and bottle, but to put the child first to both breasts and to follow this with a bottle if an insufficient quantity of milk has been obtained. The stimulating effect of nursing on the secretion of milk is thus better secured. The child should be allowed to nurse five minutes on each breast. The amount of supplementary feeding may be determined by weighing the child before and after nursing, and giving him a quantity of bottle feeding sufficient to satisfy his caloric requirements. Or, the infant may be fed by appetite. After nursing five minutes on each breast as above, he may be given a suitable cow's milk feeding and allowed five minutes at the



bottle. The latter method is less troublesome, and in the large majority of instances it is entirely satisfactory.

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## CHAPTER XIV

### ARTIFICIAL FEEDING

The successful feeding of infants—either with woman's milk or some substitute—demands that (1) the nutritional requirements be met and that (2) the food be suited to the digestion. The nutritional requirements of the infant and the peculiarities of his digestion have already been considered. In artificial feeding two further essentials must be met: (1) the food must be presented with a suitable technic and (2) contamination with bacteria and other harmful substances must be prevented. One cannot expect success if any of these factors is ignored. Simplicity in the preparation of the feeding is much to be desired; the opportunity for error is thereby minimized.

**Cow's Milk.**—Cow's milk in some form is our main reliance in infant feeding. The milk of goats or other animals is occasionally used. It is possible to rear infants on milk-free diets, but this is seldom desirable.

Cow's milk which is to be used for infant feeding should be (1) fresh, (2) clean, (3) free from preservatives. (4) It should not be skimmed or otherwise falsified. (5) It should be free from toxic substances and pathogenic bacteria and (6) the number of other organisms should not be excessive. It is desirable that the composition of the milk—particularly the fat—be as constant as possible. Mixed or herd milk is preferable to that of a single animal, since it is subject to fewer variations. The common varieties of "grade cows" should be used rather than highly bred animals; the former are less susceptible to disease and other influences affecting the milk. Stall-fed cows give a more uniform milk than pastured cows. Grazing animals often eat garlic and other substances which confer an unpleasant taste to the milk; in certain localities, poisonous herbs may be eaten which render the milk toxic.

As ordinarily handled, milk should be used within twenty-four hours after delivery. If it is kept more than forty-eight hours after milking, changes occur very rapidly, particularly in summer. When special precautions are taken in producing and handling milk, it may be safe for a longer time.

*Micro-organisms in Milk.*—Pathogenic bacteria may find their way into milk (1) from disease of the cow, (2) from dairy employees, (3) from dirt acquired from the cow, the employees or the utensils used in handling the milk. Diseases which may be acquired from the cow are: tuberculosis, streptococcus sore throat, undulant fever, anthrax, foot and mouth disease. The incidence of tuberculosis in cattle varies greatly; in communities where no attempt is made to eliminate it between 25 and 50 per cent of the cattle may be found to be infected. Tubercle bacilli are not found in the milk, however, unless the disease is advanced or unless udder lesions are present. In the United States infection with the bovine tubercle bacillus is steadily declining, owing to the stringent laws in many states requiring



the destruction of tuberculous cattle, and to the increasing prevalence of sterilizing milk for infants. There is no objection to the use of milk from cows whose only evidence of tuberculosis is a positive skin test, provided such milk is carefully sterilized. Epidemics of "septic sore throat" have not infrequently been traced to cows with streptococcus infections of the udder. It has been shown recently that infection with *brucella abortus* is widespread among cattle in this country; human infections (undulant fever) are, however, encountered only sporadically.

The majority of milk-borne epidemics arise from infected dairy employees. Typhoid, scarlet fever and septic sore throat are the diseases most frequently spread in this way. Many epidemics of typhoid have been traced to carriers. The simultaneous development of a considerable number of cases in a community should lead one to suspect the milk supply. Besides the diseases mentioned, diphtheria, cholera, dysentery and other forms of infectious diarrhea may be spread by the milk.

Although sterile cow's milk has been produced, this is not practicable. Ordinarily cow's milk contains large numbers of bacteria which are acquired from the udder of the cow, the hands of employees and the utensils in which the milk is handled. The varieties of bacteria vary somewhat with locality, but they fall into two general groups. (1) In the *lactic acid-producing* group are harmless bacteria which cause the souring of milk by fermenting lactose. Among them may be mentioned *B. lactis aerogenes*, *B. acidophilus*, *B. bulgaricus* and *Streptococcus lacticus*. In fresh milk most of the bacteria are of this group; with souring they become even more abundant and constitute 95 per cent of the milk bacteria. They are more resistant to the acid produced in fermentation than are other species which tend to die out in soured milk. (2) The second group consists of bacteria which are not strictly pathogenic, yet when present in large numbers may produce changes in the milk that cause illness in infants. This group includes organisms of the colon group: *B. coli*, *B. acidi lactici*, *B. proteus*, *B. morgani*, *B. enteritidis*, *B. faecalis alkaligenes* and certain spore-bearers such as *B. subtilis* and *B. aerogenes capsulatus* (*B. welchii*). Such bacteria may act upon the milk proteins producing various putrefactive changes. The relation of bacterial contamination to infantile diarrhea is considered elsewhere.

THE NUMBER OF BACTERIA IN MILK.—This depends upon (1) cleanliness in handling, (2) the age of the milk, and (3) the temperature. The number of bacteria in bottled milk as delivered from good dairies varies from 10,000 to 50,000 per c.c. according to season. Milk from mixed dairies delivered in cans usually ranges from 100,000 to 1,000,000, though much higher figures are often reached in hot weather. Bacteria adhere to the fat globules; the number of bacteria in cream is therefore somewhat greater than in milk.

A BACTERIOLOGICAL STANDARD FOR PURE MILK.—The bacterial count is often used as a criterion of the purity of milk; one milk commission requires that not more than 10,000 bacteria per c.c. be present; another fixes the limit at 30,000. The mere number of bacteria does not, however, show whether the milk is suitable for use. There is no evidence that the results in infant feeding are any better with a milk containing 5,000 bacteria or less, than with one containing 20,000. Nor is there any proof that one containing 50,000 bacteria is for this reason alone



injurious. Unless a preservative has been added, a low bacterial count may be taken as presumptive evidence that the milk is produced under hygienic conditions and carefully handled; in such circumstances the introduction of pathogenic organisms is improbable.

The dangers from bacterial contamination of milk may be overcome (1) by the exercise of great care in its production and handling, as a result of which the entrance and reproduction of micro-organisms is reduced to a minimum; or (2) the bacteria may be destroyed by heating. Few milks are produced under such hygienic conditions that they may safely be used in the raw state. The "certified milk" sold in most American cities is the purest milk available; the conditions under which it is produced are rigidly controlled. In view of its additional cost, it is available for only a limited number; moreover, even certified milk cannot be regarded as an absolutely safe food; epidemics have been known to be spread by it. On this account it has become customary to rely on some form of milk sterilization.

The practice of heating milk to be used for infant feeding was introduced by Soxhlet in 1886 and has since spread rapidly all over the world. Aside from the destruction of bacteria a number of changes are brought about in the milk; the antiscorbutic vitamin is injured, the lactalbumin is altered in such a way that the milk acquires a peculiar taste, and the casein subsequently coagulates in fine curds<sup>1</sup> instead of coarse ones; with higher temperatures, such as are used in autoclaving, partial caramelization of the sugar may occur giving the milk a yellowish brown tinge. Only the first of these changes is objectionable; the changes in the proteins serve only to make it more digestible. Since antiscorbutic vitamin can always be added to the diet, loss of this vitamin is of little significance and is not to be weighed against the benefits to be derived from heating milk.

The extent to which milk is altered by heat depends upon the temperature and the length of time it is maintained. Several procedures are used.

**PASTEURIZATION.**—As generally carried out this process consists in heating the milk at 150° to 155° F. (65° to 68° C.), for 30 minutes. This accomplishes the chief purpose for which milk is heated; it usually kills all pathogenic bacteria and from 98 to 99.8 per cent of the other bacteria present. The milk proteins, the coagulability of the milk and the taste are scarcely affected; the antiscorbutic vitamin is only partly destroyed. Many boards of health require the commercial pasteurization of all milk offered for sale unless it comes from "certified" dairies. Commercially pasteurized milk may, however, give a false sense of security. It may be improperly carried out or the milk may become contaminated after pasteurization. Spores are not destroyed by this process, and unless the milk is kept cool, an extensive growth of spore-bearers may occur and render the milk dangerous. Since lactic acid producing organisms have been destroyed, such milk does not taste sour and the taste may give no warning of its contamination. Even if such milk is later sterilized it

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<sup>1</sup> Some doubt exists as to the mechanism by which this is brought about. Casein itself does not appear to be "denatured" by heat. The calcium-caseinate complex is, however, affected; under extreme conditions calcium phosphate may separate out as a visible precipitate. The dissociation of calcium caseinate is probably one factor in altering the subsequent coagulability of casein. Another factor is the altered state of the lactalbumin. Lactalbumin is "denatured" by heat and separates out as a precipitate. Aggregates of this protein form nuclei upon which casein particles are adsorbed. When subsequent coagulation occurs, these tend to remain dispersed and a finer, smoother curd results. The mechanism appears to be quite similar to that which occurs when starch, gruels and other colloids are added to milk.



may be dangerous; proteolytic changes are likely to have occurred which may produce toxic symptoms. Pasteurized milk should always be kept cool (below 50° F.); it should not, as a rule, be kept more than twenty-four hours after delivery.

**BOILED MILK.**—This signifies bringing the milk approximately to 100° C. Two methods may be used; the milk may be heated directly until it boils actively, or it may be immersed in a vessel containing actively boiling water for fifteen minutes.<sup>2</sup> The destruction of bacteria by such means is more complete than with pasteurization, though spores still survive. Greater changes take place in the protein and more antiscorbutic vitamin is destroyed.

**AUTOCLAVED MILK.**—This is done by heating the milk under pressure at 110° or 115° C. for ten minutes. Spores are completely destroyed, more extensive changes in the proteins are produced. The milk acquires a yellowish-brown tinge, due to partial caramelization of the sugar. This method is useful when it is desired to keep milk for a longer period of time. Complete sterilization with destruction of spores may also be accomplished by bringing the milk to the boiling point on three successive days.

**SHOULD ALL MILK FOR INFANT FEEDING BE BOILED?**—Since some risk is involved even in feeding certified or commercially pasteurized milk, it is desirable to boil all milk used for infant feeding and to supply the antiscorbutic vitamin separately.

*Frozen Milk.*—In cold weather milk is often unavoidably delivered partially or completely frozen. Only the water in the milk freezes, the fat undergoing separation in consequence; when such milk is thawed the fat globules coalesce forming an oily layer on the surface. While older children and robust infants are seldom affected by such milk, it may produce vomiting or diarrhea in delicate infants; this is more likely to happen if the fat content is high. If, after thawing, the milk is skimmed and subsequently boiled, such disturbances are usually avoided.<sup>3</sup>

*Physical Characteristics of Cow's Milk.*—The specific gravity of cow's milk is normally between 1.028 and 1.033; a lower specific gravity should make one suspect adulteration. Microscopically the fat globules are quite similar to those of breast milk, varying from 0.76  $\mu$  to 22  $\mu$  in diameter (Koepe). Colostrum corpuscles are present during the first week after calving. Coagulation may occur from heat alone if the milk is near the souring point; colostrum of the cow coagulates readily on heating; it has generally been considered unsuitable for use with infants. The reaction of fresh milk varies between pH 6.5 and 7.2, the average being about 6.7.

*Composition of Cow's Milk.*—This varies somewhat with the breed of cattle, the chief variation being in the fat content. A typical analysis of the milk of Jersey and Holstein cows is appended:

<sup>2</sup> When the milk is heated in an open container with little agitation, a "scum" forms which consists of coagulated lactalbumin, with a certain amount of calcium phosphate and fat. This should be removed, for it is likely to clog the nipple of the feeding bottle.

<sup>3</sup> The cause of altered digestibility of frozen milk is unsettled; it has been attributed to the action of certain bacteria which grow only at low temperatures, to unusual enzyme action, to denaturation of the milk proteins, etc. It seems more probable, however, that purely physical changes are responsible; it is said that milk which has been quickly frozen and kept at a very low temperature retains its physical characteristics and its digestibility after thawing.



TABLE XVII  
PERCENTAGE COMPOSITION OF COW'S MILK \*

Constituents	Jerseys	Holsteins	Average Good Herd Milk
Solids			
Protein .....	3.91	3.39	3.50
Sugar .....	5.15	4.84	4.75
Fat .....	5.61	3.46	3.50
Minerals .....	0.74	0.74	0.75
Total solids .....	15.41	12.43	12.50
Water .....	84.59	87.57	87.50
TOTAL .....	100.00	100.00	100.00

\* Data of N. Y. State Agricultural Experiment Station.

Rich milks with a high fat content are not desirable for infant feeding; they are in fact seldom marketed. The milk sold in the United States usually contains a trifle more fat than the minimal legal requirements which vary from 3 to 3.5 per cent in different states. The composition of cow's milk is to some extent influenced by the diet; this is particularly true of its vitamin content.

DIFFERENCES BETWEEN COW'S MILK AND WOMAN'S MILK.—The chief differences are indicated in the accompanying table:

TABLE XVIII  
PERCENTAGE COMPOSITION OF COW'S MILK AND WOMAN'S MILK

Constituents	Woman's Milk		Cow's Milk	
Protein .....	1.25		3.50	
Lactalbumin .....		0.75		0.50
Casein .....		0.50		3.00
Sugar (lactose) .....	7.50		4.75	
Fat .....	3.50		3.50	
Minerals .....	0.20		0.75	
Na .....		.011		.061
K .....		.048		.154
Ca .....		.034		.122
Mg .....		.005		.013
Cl .....		.036		.116
P .....		.015		.090
Water .....	87.55		87.50	
TOTAL .....	100.00		100.00	

The table does not, however, show all of the differences between the two milks. Both the lactalbumin and the casein of the two milks possess specific immunological properties. The same may be said of the lactoglobulin which exists in small concentration in both milks. The differences in the character of the casein coagulum can be attributed to the difference in the quantity of casein present, rather than to chemical differences between the two caseins.

The fat of cow's milk differs in some respects from that of breast milk. Differences in the size and number of the fat globules have been described, and



have been thought to be important. It is highly doubtful if they are of any importance. The variation in the character of the globules in different individuals and under different conditions in the same individual is greater than species variations. There are certain chemical differences between the two fats. The chief fats of both milks are triolein, tripalmitin and tristearin, but breast milk contains considerably more of the unsaturated fat triolein. The quantity of unsaturated fat in milk is, however, greatly influenced by the fat of the diet; a mother whose diet fat is composed largely of olive oil will secrete a milk fat with an iodine value of 70 or 80, while another woman consuming butter fat may secrete a milk fat with an iodine value between 40 and 50. It is possible to feed cows in such a way that they secrete a milk fat with an iodine value within the range of human milk. Such an experiment was carried out by Schlossmann<sup>4</sup> in Düsseldorf without striking results as far as infant feeding was concerned. Cow's milk contains seven or eight times as much of the esters of the lower (volatile) fatty acids as does breast milk. As a result of these and other minor differences, the physical and chemical constants of the two fats usually differ considerably.

The carbohydrate of the two milks is identical.

As may be seen from the table, the common minerals are found in cow's milk in a concentration from two to five times as great as that of breast milk.<sup>5</sup> Two important minerals—iron and copper—are not given in the table. Figures given in the literature for the iron in milk show considerable variation, depending on the analytical method used. The concentration of iron in breast milk is of the order of magnitude of 0.0002 per cent. Cow's milk contains less than this, often only one-third as much; considerable iron may, however, be acquired from milk pails and other vessels with which the milk comes in contact; under these circumstances, cow's milk may contain nearly as much iron as breast milk. Traces of copper are found in both milks; the copper content of milk may be increased if it is handled in copper vessels. This element, although present in minute amounts, has been shown to be of importance in the synthesis of hemoglobin.

The buffer value of cow's milk is considerably greater than that of breast milk. This has been discussed elsewhere (p. 120).

Since the vitamins in milk are largely dependent on the diet, it follows that their content both in cow's milk and in human milk is quite variable. Vitamin D is usually more abundant in human milk; vitamin C is usually present in sufficient quantity in both milks, but when cow's milk is heated it is wholly or partly destroyed. The question of vitamin B deficiency in milk has been discussed elsewhere. The A factor is abundant, but is removed when the milk is skimmed.

Enzymes have been described in both milks. They are abundant in cow's milk, where they are probably associated with the bacteria. It is probable that such enzymes are of little importance, for as a rule they do not survive the acidity of the stomach.

Cow's milk may contain antibodies of benefit to the calf, while breast milk

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<sup>4</sup> Quoted by Engel, *Arch. f. Kinderh.*, 1910, 53: 259.

<sup>5</sup> The figures are taken from analyses of Holt, Courtney and Fales. The cow's milk was obtained from stall-fed animals. Recent observations have shown that higher figures for calcium and phosphorus are obtained when cows are pastured, particularly in summer. The calcium may be as high as 0.140 per cent, the phosphorus as high as 0.110 per cent.



may contain diphtheria antitoxin and other antibodies useful to the infant. It would appear, however, that the importance of such a protective mechanism for the infant has been greatly overemphasized in the past. It is questionable if the few antibodies that have been found in milk survive the acidity of the stomach. The immunity of the newly born infant to certain diseases is not to be explained in this way. Many attempts have been made to show that the breast-fed infant is more resistant to infections than the infant reared on cow's milk. Provided the nutrition of the artificially fed infant has been properly maintained, it does not appear that he is more susceptible to infection.

**The Modification of Cow's Milk.**—It was appreciated at an early date that infants fed on cow's milk were far more subject to disorders of digestion than were nursing infants. Until the latter part of the nineteenth century, bacterial contamination of milk was unquestionably responsible for much of the difficulty. With the improvement in standards of cleanliness in milk production, and the more general adoption of some form of milk sterilization, this menace has largely disappeared. Even pure cow's milk is, however, less digestible than breast milk. Some robust infants will thrive on it, but for the majority it is an unsuitable food. The history of artificial feeding has been one long series of attempts to modify cow's milk in such a way as to make it suitable for infants. As one or another difference between the two milks became appreciated, emphasis would be laid on correcting this particular factor. Such modifications were not always beneficial; sometimes they resulted in the reduction of some essential constituent of the diet which was not appreciated at the time. Efforts to render cow's milk more digestible not infrequently led to failure because the energy requirements were not met or because some essential amino-acid, vitamin or mineral constituent was inadequately supplied. With a wider knowledge of nutrition, such mistakes are more easily avoided. For a number of years it has been possible to feed successfully the large majority of infants who must be reared on cow's milk. The more recent developments in the adaptation of cow's milk to infant feeding have served chiefly to provide additional methods of doing this; only to a very limited extent have they made possible the treatment of hitherto refractory conditions.

It is possible to modify cow's milk in a great variety of ways so as to make it an entirely satisfactory food for most infants. Different methods have their particular advantages, but no one method can be recommended above all others.

TABLE XIX  
PERCENTAGE DISTRIBUTION OF CALORIES

	Protein	Fat	Carbohydrate
Cow's milk .....	22	49	29
Cow's milk * (common modification)...	15	35	50
Breast milk .....	8	47	45

\* The figures given are only approximate.

The most successful modifications have, however, had certain features in common: a reduction in the protein and fat and an increase in the carbohydrate. The proportion of calories distributed as protein, fat and carbohydrate in whole cow's milk, cow's milk as commonly modified, and in breast milk is shown in the table.



The reduction in the proportion of protein and fat ingested is desirable for several reasons.

A diet which contains too high a proportion of protein as compared with carbohydrate may lead to increased bacterial putrefaction in the intestine; eventually the nutrition may suffer (see *Milchnährschaden*). A high protein diet increases the water requirements; the energy requirements are also increased because of the marked specific dynamic action of this type of foodstuff; the additional food may tax the digestive capacity. It was long believed that the protein of cow's milk was more difficult of digestion than that of breast milk; this view requires qualification. Chemical studies have shown that hydrolysis of proteins and absorption of protein split products is remarkably complete on a diet of cow's milk, even in the presence of grave nutritional disorders. Only traces of undigested protein are ordinarily found in the stools (see page 122). The digestion of protein may, however, be mechanically impeded by the large casein curds formed in the stomach, particularly when raw milk is used. The "work" of digestion may thereby be increased, even though digestion is ultimately complete. The mechanical difficulty with the digestion of cow's milk curd is an added reason for diminishing the protein intake when raw or possibly when pasteurized milk is fed. With other forms of milk the curd is so modified as to be easily digested and this reason drops out. In reducing the protein intake it is unwise to give as little as the nursing infant receives; such a diet, if long continued, may result in a deficiency of essential amino-acids, and growth may suffer.

Most infants can take a high proportion of cow's milk fat; this fact was amply demonstrated in the days when it was customary to employ mixtures of top-milk or cream in infant feeding. The gradual abandonment of such high fat formulas, and the more general use of feedings in which the daily intake of fat is somewhat less than that of unaltered cow's milk, has been due to several reasons. A certain number of infants who are given a high proportion of cow's milk fat are said to develop as the result of this food an intolerance for fat which may persist for weeks and even months; this is less frequently encountered with a lower fat intake. Metabolism experiments have shown that cow's milk fat is not quite so completely absorbed as breast milk fat. This difference is due partly to the higher concentration of minerals in cow's milk, and partly to the chemical or physical differences between the two fats. Special modifications have been devised to overcome one or another of these physical and chemical differences: *homogenized milks*, in which the material is forced through a fine aperture to decrease the size of the emulsified fat particles; *decalcified milks*; the *butter-flour mixtures* developed in Europe to remove the excess of volatile fatty acids by boiling butter and incorporating this in a mixture of flour and milk; and, lastly, various mixtures of animal and vegetable fats have been substituted for butter in the milk, mixtures in which the attempt is made to approximate certain of the physical and chemical constants of human milk fat. The claim that these various modifications increase the digestibility of the fat and make it possible to feed more without the risk of producing intolerance does not appear to be well founded. Although they have all been used with success, their superiority over feedings prepared with untreated fat has not been established. We are inclined to doubt



the correctness of the view that cow's milk fat is more likely to produce fat intolerance than the fat of breast milk, and to question the practical significance of the minor differences in fat absorption that have been found. Nevertheless, the belief that it was unwise to feed equal amounts of cow's milk fat has led to the general practice of reducing the intake of fat (together with that of the protein) and to compensate for these changes by giving additional carbohydrate.

Carbohydrate may be added to milk in many forms—simple sugars, polysaccharides or mixtures may be used. There appears to be no particular advantage in giving monosaccharides, for the disaccharides are always readily inverted. Of the double sugars, *lactose* would seem the logical one to use since it is the natural carbohydrate of milk; as a matter of fact, however, there seems to be no advantage in giving lactose. Pure lactose is expensive; most commercial preparations contain impurities which have a slight laxative action. Pure *maltose* is not used for infant feeding. *Cane sugar* (sucrose, saccharose) is under almost all circumstances an entirely satisfactory product for use with infants; it is inexpensive and is always available in pure form.

There are times, however, when it seems advantageous to give part of the carbohydrate in the form of polysaccharide; this is the case when diarrhea is present or when large amounts of sugar are to be fed. Since time is required for the hydrolysis of the higher carbohydrate, the absorption of sugar is more gradual, and an alimentary glycosuria is less likely to develop. The amount of fermentable sugar present in the intestine at one time is limited; hence fermentation is less likely to take place. A theoretical advantage claimed for the polysaccharides is that the osmotic pressure of these substances is considerably less than that of the sugar resulting from their hydrolysis; there is therefore less tendency for water to be drawn into the intestine and perhaps lost in the stool when large amounts of carbohydrate are fed in this form. Mixtures of dextrin and maltose are usually employed when a polysaccharide is desired. A number of preparations are on the market which differ somewhat in their properties. The liquid malt extracts<sup>6</sup> should not be used in diarrhea; they contain impurities which are somewhat laxative, and are therefore sometimes used in the treatment of constipation. "Malted milk," "Mellin's food," "dextri-maltose" and "Karo corn syrup" are not laxative and are all satisfactory preparations; the first three are proprietary preparations and consequently expensive; corn syrup is one of the cheapest forms of carbohydrate available, and in recent years it has become increasingly popular for infant feeding. Other carbohydrate mixtures which should be included in this group are molasses and honey. These are more frequently employed in Europe than in this country; they appear to possess no particular advantages.

The addition of carbohydrate in the form of starch is sometimes useful. Thin gruels were once widely used as diluents for raw milk, because of the effect of starch on curd formation. With boiled milk this is not necessary. At present the chief use of starch is to thicken the feeding. Thick feedings are of value in certain cases of vomiting. The starch should be thoroughly cooked for young infants, since their ability to digest raw starch is limited. An excess of starch appears in the stools unchanged; it is not harmful.

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<sup>6</sup> Loefflund's extract of malt, Borchardt's malt extract, malt soup extracts.



Cow's milk may be adapted for infant feeding along the lines just discussed: (1) by dilution, with subsequent addition of carbohydrate, or (2) by adding carbohydrate to whole milk and reducing the quantity of food taken. Each of these methods serves the purpose of diminishing the intake of protein and fat and increasing that of carbohydrate. Dilution of milk is the time-honored method. With raw milk a considerable degree of dilution is necessary. The objections to this procedure resulted from the high degree of dilution often employed; mixtures were frequently recommended containing between 10 and 15 calories per ounce—little more than half the caloric value of breast milk. A food of such a low caloric value makes it necessary to give large quantities if the energy requirements are to be met; the danger is that the infant will either be underfed or that his stomach will be overloaded and that he will receive an unnecessarily large intake of water.

In recent years the pendulum has swung in the opposite direction. The ease with which whole cow's milk can be digested when it has been suitably treated has led to the practice of feeding undiluted whole milk with additional carbohydrate. Such mixtures are more concentrated than breast milk and often contain 30 calories or more per ounce. The routine use of formulas of this kind is also open to criticism; the child so fed will receive considerably less water than the normal breast-fed infant; consequently, he has a smaller margin of safety to protect him in conditions in which an extra demand for water is made (fever, external heat, overclothing, high humidity, etc.). Additional water may, of course, be given between feedings, but this adds to the nursing care of the infant; in institutions where this may be made a matter of routine this is less objectionable than in dispensary or private practice, where the regular administration of additional water is likely to be neglected.

Although in particular circumstances either a dilute or a concentrated food may be indicated, our preference in the routine feeding of infants is to avoid both of these extremes and to give a food which is isocaloric with breast milk (containing 20 calories per ounce). The following formula accomplishes this: whole milk 7 ounces, water 3 ounces, sugar  $\frac{1}{2}$  ounce. This may be prepared from boiled milk, fermented milk or acidified milk; dried or evaporated milk may be used if the composition of the original milk is first reconstituted by addition of water. Such a formula gives a percentage distribution of calories (protein 15 per cent, fat 35 per cent, carbohydrate 50 per cent) which has been found by experience to be suitable for artificial feeding with cow's milk.

### DIETARY OF THE ARTIFICIALLY FED INFANT

A large variety of methods of preparing milk and commercial preparations are available for use in infant feeding. A knowledge of their merits and limitations is essential if one is to use or avoid them successfully.

**Boiled Milk.**—Our preference is for this as a routine food for infants. Changes due to bacterial contamination in the handling as well as in the production of milk are largely eliminated. Sufficient alteration is brought about by the heating to make the milk digestible without recourse to high dilutions of low caloric value. Moreover, this food combines the advantage of cheapness and simplicity of



preparation. Directions for the preparation of feedings are given in another place.

**Raw Milk and Pasteurized Milk.**—The peculiarity of these foods lies in the large, tough curds formed, which are less easily manipulated by the infant's stomach. Pasteurization modifies the curd slightly, but the difference between this and the coagulum of raw milk is not great. Although many infants will take concentrated mixtures of raw or pasteurized milk, minor gastro-intestinal symptoms are not uncommon, particularly when such milk is first started. It is therefore wiser to begin with dilute mixtures. The standard cow's milk formula containing 20 calories per ounce (see page 152) should be diluted until it contains 12 or 15 calories per ounce. The volume of food given should not exceed that of a normal breast-fed infant of the same age. This will result in underfeeding for a time; when it is clear that no digestive disturbance is produced the strength of the food may be cautiously increased, the usual formula with adequate caloric intake being reached in the course of a few days. Should digestive disturbances appear which can be attributed to the curd, starch may be added to the feeding. The short period of underfeeding may cause a temporary arrest or even a slight loss of weight; as a rule, this is promptly regained. Although this method of feeding has been used with success for years, we do not consider it the feeding of choice. The conservatism which must be employed in starting such feedings or returning to them after a digestive upset is certainly not an asset; the risk of introducing pathogenic bacteria into the feeding is not eliminated. Since vitamin C can readily be given separately in the diet, there would appear to be no particular advantage in using raw milk or milk which has only been pasteurized commercially.

**Skimmed Milk.**—Most commercial skimmed milks contain about 1 per cent of fat. Skimmed milk is not to be recommended for general use in infant feeding. Reduction of the fat is, however, indicated in conditions of fat intolerance, which may result from infections, from overfeeding of fat, etc. Some infants have naturally a low tolerance for fat. In using skimmed or partially skimmed milk, one should always make sure that cod liver oil or some other source of fat-soluble vitamins is also given.

**Dried Milk.**—This is prepared by spraying milk into a hot air chamber or by bringing it into contact with heated revolving drums. The water of the milk is volatilized almost instantly and the dried milk remains as a fine, flaky, white or yellowish-white powder. When sealed in nitrogen in tin cans, it keeps for months and even years. It is usually prepared from pasteurized milk and is practically sterile. The heating process alters the proteins somewhat more than is the case with boiled milk; fine curds are formed which are readily digestible. Vitamin C is not greatly damaged by this process; much of it is, however, lost in the original pasteurization of the milk and it should therefore always be supplied independently. In recent years a great many commercial preparations of dried milk have been put on the market. These may be divided into four classes: (1) dried whole milk, (2) dried skimmed or partially skimmed milk, (3) special products, such as lactic acid milk, protein milk, and (4) various modifications of milk designed for use in infant feeding.

The best known examples of dried whole milk in this country are Klim and the dried milk prepared by Mead, Johnson & Company. When one part by weight



is added to eight parts of water, the composition approximates that of whole cow's milk. (Four level tablespoonfuls are the equivalent of one ounce by weight.) Dried whole milk is an entirely satisfactory food for infants; it has been used routinely in the infant's wards of the Johns Hopkins Hospital for a number of years. It probably possesses some advantage over boiled milk when concentrated feedings are desired. It is particularly useful when good fresh milk is not obtainable. In warm climates and when facilities for proper refrigeration are lacking, the use of dried milk greatly diminishes the risk of bacterial contamination. Mainly for this reason, we welcome the present increase in its use. The cost of dried milk is slightly greater than that of the best grade of pasteurized milk.

Half-skimmed dried milk may be used when a reduction of the fat is indicated. The keeping qualities are better than is the case with whole milk; it is therefore not sealed in nitrogen. The best known preparations of this type are Dryco, Mead's half-skimmed milk powder, and that prepared by the Merrell-Soule Company. Its percentage composition is given in the following table:

TABLE XX  
PERCENTAGE COMPOSITION OF HALF-SKIMMED DRIED MILK

	Protein	Fat	Carbo- hydrate	Mineral	Calories per Ounce
Half-skimmed milk powder .....	34.	12.	44.	7.	130
When diluted 1 to 8 by weight *...	4.25	1.5	5.5	0.875	16
Distribution of calories.....	32	26	42		

\* Eight level tablespoonfuls are equivalent to one ounce by weight. Feedings of this type have been used successfully in normal infants.

The proprietary modifications of dried milk will be discussed elsewhere.

**Evaporated Milk.**—This is prepared by evaporating milk *in vacuo* at 55° to 60° C. to approximately half its volume; the product is then “homogenized” by forcing it through a fine aperture, which causes a much finer subdivision of the fat particles; it is then sealed in cans and autoclaved at 116° C. for a sufficient

TABLE XXI  
PERCENTAGE COMPOSITION OF EVAPORATED MILK

Milk	Protein	Fat	Carbo- hydrate	Mineral	Calories per Ounce
Evaporated milk .....	7.	7.85	10.	1.6	44
Evaporated milk, diluted with an equal volume of water.....	3.5	3.9	5.	0.8	22
Distribution of calories.....	20	51	29		

time to destroy all spores. It is completely sterile.<sup>7</sup> Because of the high temperature to which it is subjected the protein is further altered than is the case with boiled or dried milk. Homogenization of the fat also affects the character of the curd, which is softer and more gelatinous than that of any other heated milk.

The composition of evaporated milk is standardized by government requirements and is given in Table XXI.

<sup>7</sup> Evaporated milk is sometimes sold in bulk. This is not a sterile product and should be kept cool and used promptly.



Evaporated milk is a satisfactory food for normal infants, provided vitamin C is supplied. An appropriate modification with additional carbohydrate, containing 20 calories per ounce, may be prepared by taking: Evaporated milk 3 ounces, water 7 ounces, sugar 1/2 ounce.

The advantages of evaporated milk are much the same as those of dried milk. Sealed in cans it will keep indefinitely. On account of its ease of digestion it is particularly useful for the preparation of concentrated feedings, as may be needed in the case of many premature infants and those suffering from chronic disturbances of digestion.

**Sweetened Condensed Milk.**—This is prepared by evaporating milk *in vacuo* to a little less than half its original volume. It is not sterilized, but is preserved by the addition of sucrose. The average composition is as follows:

TABLE XXII  
PERCENTAGE COMPOSITION OF CONDENSED MILK

Milk	Protein	Fat	Carbo- hydrate	Mineral	Calories per Ounce
Condensed milk .....	8	8	55	1.8	100
Condensed milk with 3 parts of water added .....	2	2	14	0.45	25
Condensed milk with 6 parts of water added .....	1.1	1.1	8	0.26	14
Distribution of calories.....	10	22	68		

Sweetened condensed milk is not a suitable food for infants; it contains too high a proportion of carbohydrate and too little fat and protein. Infants fed on it may gain rapidly in weight, but they are fat, their musculature is flabby and their resistance to disease appears to be diminished. Evaporated milk possesses all the advantages of condensed milk and none of its disadvantages; it has largely replaced condensed milk for infant feeding.

**Fermented Milks.**—When milk undergoes souring a number of changes take place: part of the lactose is fermented with the production of lactic acid; the acidity causes the casein to coagulate; organisms of the lactic acid group completely overrun the other bacteria of milk. The observation that sour milk had some advantage over ordinary fresh milk is an old one; much doubt has existed, however, as to which of the changes was responsible for this. It now seems reasonably clear that the merits of sour milk are not due to its slightly lower carbohydrate content or to the excess of lactic acid organisms, but rather to the acidity and to the altered character of the casein curds formed. A variety of fermented milk preparations are available.

**Buttermilk.**—The original buttermilk of commerce was made from milk which had been allowed to sour naturally, the fat of which was removed by churning. Such milk was often grossly contaminated by bacteria and was quite variable in composition. Buttermilk is now made by inoculating sterile skimmed milk with some lactic acid producing organism. Table XXIII gives an average composition. Some dairies prepare buttermilk with a specified fat content, such as 1 per cent,



or fat-free buttermilk. The caloric value may be raised by suitable additions of carbohydrate. Buttermilk may be used when there is some indication for reducing the fat. A change to a food low in fat and high in carbohydrate is likely to be

TABLE XXIII  
AVERAGE COMPOSITION OF BUTTERMILK

Protein .....	3.6	per cent
Fat .....	0.5	per cent
Lactose .....	4.0	per cent
Lactic Acid .....	0.7	per cent
Minerals .....	0.75	per cent
Calories .....	12	per ounce

followed—even in moderately severe nutritional disturbances—by a gain in weight. This is due to increased retention of water and minerals and does not necessarily mean that an improvement in nutrition has taken place.

*Protein Milk (Eiweissmilch).*—This is a modification of milk introduced some years ago by Finkelstein for the treatment of infants with diarrhea. It was originally designed to provide a food low in carbohydrate, but it now appears that its advantages are chiefly due to other properties. When prepared as directed below <sup>8</sup> its percentage composition is approximately as follows:

TABLE XXIV  
PERCENTAGE COMPOSITION OF PROTEIN MILK

Milk	Protein	Sugar	Fat	Mineral	Calories per Ounce
Usual protein milk.....	3.75	1.8	3.0-3.5	0.65	13
Reënforced protein milk .....	4.55	3.8	3.25-3.75	1.0	19 to 20

The fat content varies somewhat according to the technic of preparation; the mineral content is high in calcium and magnesium. When properly made, protein milk is almost homogeneous; the fine curds will readily pass through a rubber nipple if the bottle is shaken. The milk may be warmed to the usual feeding temperature, but if heated much above this the curd separates.

It seems probable that the value of protein milk in the treatment of diarrhea does not depend to any great extent upon the low carbohydrate as originally supposed, although it is likely that the high ratio of protein to carbohydrate does to some extent check bacterial fermentation. Protein milk possesses the advantages of all acid milks; in addition, because of its high content of fat and of alkaline earth minerals it tends to produce formed stools which are rich in calcium and magnesium soaps; this gives symptomatic relief in diarrhea. Protein milk is not to be regarded as an infant food suitable for prolonged use, but rather as a

<sup>8</sup> A quart of whole milk is curdled with rennin. When firmly coagulated it is poured on two layers of cheesecloth and suspended for one hour to drain off the whey. The dry curd is rubbed through a vegetable masher or some similar instrument, with gradual addition of one pint of buttermilk. Enough boiled water is added to make one quart. A modification often used (reënforced protein milk) is to add one quart of buttermilk and no water to the curd from one quart of milk. This increases the sugar, the salts and the protein and raises the caloric value to about 20 per ounce.



therapeutic agent for acute and chronic disturbances of nutrition, particularly those associated with diarrhea.

*Fermented Whole Milk.*—This is prepared by sterilizing the milk and subsequently inoculating it with a culture of some lactic acid producing organism; those most frequently employed are *B. acidophilus*, *B. bulgaricus*, *B. acidilactici* or *Streptococcus lacticus*; mixed cultures are sometimes used. After inoculation the milk is incubated at 80° to 85° F. for six to twelve hours according to the degree of acidity desired; it is then put on ice, where it will keep for several days with comparatively little change. Fermented milk has a creamy consistency due to the extremely fine precipitation of casein curds.

**Unfermented Acid Milks.**—Acid milks may be prepared by the direct addition of various acids to milk. In order to secure curds sufficiently fine to pass through the nipple of a feeding bottle it is necessary to add the acid very slowly and with constant stirring; the milk should be ice-cold. Sufficient acid is usually added to bring the milk approximately to pH 4; the quantity added will depend upon the acid used. If lactic acid is used, as recommended by Marriott, the quantity should be one teaspoonful of U.S.P. lactic acid (85 per cent) to one pint of whole milk. With hydrochloric acid, as recommended by Faber, the quantity used is 4 ounces of decinormal HCl to one pint of milk. With acetic acid, as used by Dunham, one dram of U.S.P. acid (36 per cent) is added to one pint of milk. Citric acid and fruit juices containing citric acid have also been used as acidifying agents. The juices of the citrus fruits have the advantage of supplying antiscorbutic vitamin, but it is difficult, particularly with orange juice, to produce sufficient acidification of the milk without greatly diluting it. When citric acid is used, the quantity should be 2 grams of anhydrous acid to 1 pint of milk. The curds produced by the addition of citric acid or citrus fruit juices are much finer than those produced by the addition of lactic acid, acetic acid or hydrochloric acid; with citric acid it is not necessary to be so careful about adding the acid slowly. Organic acids added to milk are oxidized and are excreted as carbonic acid through the lungs. With mineral acids, such as hydrochloric, the acid radical is excreted through the kidneys. In the presence of adequate respiratory or kidney function, no difficulty in excreting this small amount of additional acid need be feared.

In recent years fermented and acidified milks have been widely advocated for the feeding of normal infants. The advantages claimed for this type of feeding are numerous: (1) the protein is rendered more digestible by the acid coagulation so that concentrated milk feedings may be employed; (2) the added acid suffices to overcome the higher buffer value of cow's milk (see page 120); (3) the acidity inhibits the growth of certain bacteria, and (4) acidity of the intestinal contents favors calcium absorption and is said to be of value in the treatment of tetany. We do not consider that these arguments are altogether well founded. It is unsafe to rely upon acidity to destroy harmful bacteria in milk; milk should be sterilized in any case. Although it has been shown that calcium absorption may be increased by acidification of milk, this effect is an inconstant one; not infrequently the increased acidity of the food stimulates the flow of the alkaline digestive juices to such an extent that the reaction of the intestinal content is more alkaline instead of more acid and calcium absorption is impaired rather than



improved. Although there is no question that acid milk is a satisfactory food for most infants, it would seem that it should offer some definite advantage in order to justify the additional labor or expense involved in its preparation. Up to the present no evidence has been brought forward to show that infants fed upon acid milk thrive better, or are any less susceptible to infections or disturbances of digestion than infants fed on boiled milk. Judged by empirical evidence, the high buffer value of cow's milk appears to be of no great importance in interfering with digestion. This view is well attested by the experience of past years when it was customary to add alkali in the form of lime water to milk in order to increase its digestibility, with results which were considered excellent. Marriott has called attention to a group of infants whose gastric acid secretion is apparently above the average, who will vomit when given acid milk but are able to retain sweet milk.

In acute and chronic disturbances of nutrition it is probable that fermented and acidified milks possess some real advantage; we employ them not infrequently in that belief. They provide one convenient method for preparing a concentrated feeding.

**Butter-flour Milk Mixtures.**—The original object of such mixtures was to remove the excess of volatile fatty acids in cow's milk, making it possible to feed a higher proportion of fat. A number of mixtures of this type have been devised in Europe, the best known being that of Czerny and Kleinschmidt. In the preparation of this food, a butter-flour stock is first prepared which contains: butter 2 level tablespoonfuls, flour 2½ level tablespoonfuls, cane sugar 1 level tablespoonful, and water 10 ounces. The butter is heated in a frying pan until foaming ceases, the flour is then mixed in and cooked for 5 minutes, the sugar and water are then added. This butter-flour stock is mixed with an equal volume of milk to make the final feeding mixture which has the following composition:

TABLE XXV  
PERCENTAGE COMPOSITION OF BUTTER-FLOUR MILK

	Protein	Fat	Carbo- hydrate	Mineral	Calories per Ounce
Composition .....	2	5.1	6.9	0.37	26
Distribution of calories.....	10	56	34	..	..

Butter-flour milk is readily digestible, although there is no evidence that the fat is better tolerated as the result of the special treatment employed.<sup>9</sup> Since the proportion of different foodstuffs does not differ greatly from that of breast milk, the stools are quite similar in character to breast milk stools. Butter-flour mixtures are useful when a high caloric feeding is desired; the protein, however, is somewhat low for a food which contains only cow's milk protein; it is therefore unwise to continue with this type of food for a long period.

**Cereal Gruels.**—Thin gruels may be prepared from barley, rice, wheat, oat, or arrowroot flour by using 1 tablespoonful of flour to 12 ounces of water and

<sup>9</sup> Personal observations have shown that the reduction in volatile fatty acid content, when butter is heated as directed, is altogether negligible. The foaming which occurs is not due to the escape of volatile acids, but to steam. The volatile fatty acids of cow's milk fat are not free but are combined as triglycerides, which do not have low boiling points.



cooking for twenty minutes. These were formerly used a great deal in diluting raw milk for young infants; they served to modify the character of the casein curds in the stomach. Such cereal waters are sometimes given in cases of acute digestive disturbance when milk is omitted; they can scarcely be considered as foods, however, for their caloric value is extremely low, being two calories to the ounce.

Thick gruels are made by mixing the flour with water or milk in the proportion of 1 ounce (3 tablespoonfuls) to 10 or 12 ounces, with a little salt added, and cooking for one hour or more in a double boiler to a thick paste. If made with milk the caloric value is about twenty-eight per ounce; if made with water, about eighteen. Any of the common cereals made from whole grain may be similarly prepared and used.

**Infant Foods.**—The proprietary foods of to-day reflect to a certain extent the recent advances in our knowledge of nutrition. Many of them are now adequately supplied with vitamins. A number of foods which contain excessive quantities of carbohydrate are no longer advertised as complete infant foods, but as milk modifiers. Several preparations are on the market which consist of milk modifications quite satisfactory for infant feeding. The proprietary foods fall into several definite groups:

*Complete Milk Foods.*—The best known examples of this type are “S.M.A.,” “Recolac,” “Similac” and “Lactogen.” They represent attempts to approximate the composition of breast milk by dilution and suitable addition of carbohydrate. In S.M.A., Recolac and Similac the fat consists of a mixture of vegetable and animal fats, which, besides containing the fat-soluble vitamins, is designed to approximate many of the physical and chemical characteristics of breast milk fat. This latter point, in particular, is emphasized in the case of S.M.A. These preparations are marketed in dried form; some may also be obtained in evaporated liquid form. Although they may be used with success in infant feeding, there is no known advantage to be derived from them which justifies their additional expense. Neither the addition of carbohydrate nor of fat-soluble vitamins to the feeding is a matter of such difficulty as to necessitate their being specially incorporated in the milk. It has recently been shown that these synthetic fat mixtures are no better absorbed or tolerated than cow’s milk fat. Moreover, it is questionable whether it is wise to give as low a protein as that of breast milk when cow’s milk is the source of protein. Lactogen is a product consisting of cow’s milk modified by the addition of lactose.

*“Incomplete” Milk Foods.*—These are foods which contain a small amount of dried milk, but consist largely of carbohydrates; they are suitable only for additions to milk. Nestlé’s food is probably the best known of this group. It contains in addition to milk, cane sugar, starch, dextrins, maltose, vitamins A and B and a variety of mineral salts. Malted milk consists of one-third dried milk and two-thirds carbohydrates—chiefly dextrins and maltose.

*Carbohydrate Foods.*—These are of two varieties: (a) the *malted foods*, which are composed chiefly of dextrin-maltose mixtures. Among these may be mentioned Mellin’s food, “dextri-maltose” and various malt-dextrin milk modifiers and malt extracts; and (b) the *farinaceous foods*, which consist of flour in which a small



proportion has been dextrinized. In this latter group may be mentioned Imperial granum, Ridge's food, Hubbell's prepared wheat and Robinson's patent barley. There is no particular objection to the use of these carbohydrate preparations or the carbohydrate milk mixtures if they are used with a knowledge of what they contain. Some of them are advertised only to the medical profession; others are forced upon the public by skillful advertising, which is likely to convey the impression that the product possesses mysterious properties, which is far from being the case. The use of these proprietary preparations always involves unnecessary expense.

*Special Products.*—Dried preparations of protein milk and lactic acid milk have already been mentioned. A number of dried curd preparations are available such as "Casec," "Laroson" and "Protolac." The dried curd consists largely of calcium caseinate in which some fat has been enmeshed during coagulation. When added to milk mixtures this tends to produce constipated soapy stools, similar to those found with protein milk. When curd is to be incorporated in a milk formula, these dried preparations are convenient to use; freshly prepared curd is sometimes given to older children with diarrhea.

*Goat's Milk.*—This is used in certain parts of the world where cow's milk is not available. Its composition is quite similar to that of cow's milk:

TABLE XXVI  
COMPOSITION OF GOAT'S MILK

Protein .....	4.25 per cent
Fat .....	4 to 6 per cent
Lactose .....	4.5 per cent
Calories .....	23 to 26 per ounce

It contains a slightly greater amount of lactalbumin and somewhat more fat than the average cow's milk; these slight differences may be neglected in infant feeding. It has been claimed that goat's milk possesses peculiar advantages in acute and chronic nutritional disturbances, but this claim does not appear to be warranted. Goat's milk is, however, useful in cases of hypersensitiveness to cow's milk. Since goat's milk may contain pathogenic organisms it should always be sterilized; dried or evaporated goat's milk is also available. The German literature contains many references to an obscure form of anemia developing in some instances when goat's milk has been fed. This condition is discussed elsewhere.

**Diet with Intolerance to Cow's Milk Protein.**—An infant may be allergic to any of the proteins of cow's milk: casein, lactalbumin or globulin. In nearly all instances, the hypersensitiveness is to the lactalbumin alone. Lactalbumin is denatured by heating; consequently boiling or, better still, autoclaving the cow's milk may enable the child to take it. Since lactalbumins are species-specific, a change to milk of another species such as goat's milk is usually successful. With hypersensitiveness to casein, heating the milk is ineffectual; a change to the milk of another species may be effective, but this is less likely to be the case than with albumin, since the casein of different milks is not as specific as the albumin. Extreme hypersensitiveness to cow casein is usually associated with some degree



of hypersensitiveness to goat casein. In these circumstances it is usually advisable to employ milk-free diets. The protein needs can often be met by various meat and egg preparations; soy bean flour<sup>10</sup> has been used with some success in cases of this type, the fat being provided in the form of butter or egg yolk. With a milk-free diet, one should be certain that vitamin and mineral requirements are met; calcium<sup>11</sup> in particular is likely to be deficient. Diets of this kind are troublesome to prepare and should not be employed without definite indications. It is a common error to ascribe digestive symptoms to intolerance to cow's milk when in reality they are due to quite different causes. Food allergy is not necessarily of lifelong duration; in many cases it tends to diminish spontaneously as time passes. In the case of allergy to cow's milk, however, one should not wait for the hypersensitiveness to disappear spontaneously. A definite regimen of desensitization should be undertaken.

**Apparatus for the Preparation of the Feeding.**—This includes a graduate, a standard tablespoon or one-ounce measure, a receptacle for mixing the food, a funnel, feeding bottles, nipples, bottle brushes, absorbent cotton or rubber caps for the bottles and some sort of heater. The graduated cylindrical bottles with wide mouths are to be preferred, since they can be readily cleaned. Bottles of Pyrex glass or other glass capable of resisting sudden changes of temperature are a great convenience if the food is sterilized in the bottles. The hole in the nipple should be large enough to permit the milk to drop readily when the bottle is inverted, but not so large that it will flow in a stream. Nipples should be rinsed in cold water after use, then sterilized or scalded with boiling water, shaken dry and kept in a covered jar. Bottles should be rinsed first with cold water, then washed with hot soapsuds and a bottle brush. Unless the feeding is to be sterilized in the bottles, they should be rinsed in boiling water.

**Directions for Preparing Food.**—If facilities for refrigeration are adequate, all the food needed for twenty-four hours may be prepared at one time. The dairy milk bottle should be inverted several times to insure an even distribution of the fat. The appropriate amounts of milk, water and sugar are mixed together and when the sugar<sup>12</sup> is dissolved the mixture may be boiled in a saucepan for at least a minute, cooled, the scum removed, and the formula poured into feeding bottles. With bottles of unbreakable glass the hot formula may be poured in directly. The bottles should be capped or stoppered with cotton and stood in cold water until quite cool before they are put in the icebox.

The feeding may be conveniently sterilized in the feeding bottles. After thoroughly mixing the formula and dissolving the sugar the appropriate quantity is measured out into each bottle; the bottles are then stoppered and stood in a pail of boiling water for at least fifteen minutes. The level of the water outside the bottle should be as high as that of the milk inside the bottle. A bottle rack is a convenience when the milk is sterilized in this way.

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<sup>10</sup> A complete infant food is marketed under the name "Sobee" which consists of soy bean flour with addition of barley flour, vegetable fats and minerals.

<sup>11</sup> An adequate amount of calcium per day for a growing infant is provided by 45 grains (3 grams) of calcium lactate or 20 grains (1.3 gram) of calcium carbonate.

<sup>12</sup> Added carbohydrates other than cane sugar are often better dissolved in the water before mixing with milk. When liquid preparations like corn syrup or malt soup extract are used, their measurement is considerably facilitated by warming.



**Directions for Feeding.**—The food should be warmed to 100° F. by placing the bottle in warm water for a few minutes. The temperature of the milk may be tested by pouring a few drops upon the inner surface of the wrist, where it should feel warm but not hot. A bottle should not be warmed over for a second feeding.

An infant should not be more than fifteen minutes in taking his food and should not sleep with the nipple in his mouth. The bottle should be placed or held in such a position that the nipple is kept full. After feeding, the infant should be held upright over the nurse's shoulder and patted on the back to allow him to bring up such air as he may have swallowed. He is then placed in his crib and left alone. It is important that regularity in feeding be observed.

FEEDING OF HEALTHY INFANTS DURING THE FIRST SIX MONTHS

**How to Begin.**—A suitable milk feeding for the majority of infants can be devised as follows:

- 1. Estimate the probable number of calories required in twenty-four hours, allowing 45 calories per pound of body weight (100 per kilogram).
- 2. The total caloric requirement, divided by 20, gives the needed number of ounces of the standard formula:<sup>13</sup>

	Ounces
Whole milk *	7
Cane sugar	½
Water, up to	10

\* The cleanest milk that the family's circumstances will afford.

If the daily requirement, in ounces of this mixture, is not an even multiple of 10, it is wisest in the interests of accurate measurement to make up 20, 30, or 40 ounces, even if some is to be discarded.

- 3. The formula is divided equally among 4, 5, or 6 feeding bottles, according to the schedule chosen.

The essential thing in feeding is the amount of food given in the twenty-four hours. The number of feedings into which this is divided and the interval between them is of secondary importance. Infants differ in their behavior to a schedule. Some do better with relatively large feedings at longer intervals; others thrive best with smaller feedings given oftener; no hard and fast rule can be laid down. The large majority of healthy infants can be readily trained to take their feedings at four-hour intervals from the beginning. We have several times seen infants as young as six weeks of age thrive and be perfectly content on four feedings a day, with either a four- or a five-hour interval. The smaller number of feedings materially lessens the labor of the mother or nurse. On the other hand, a few infants seem more comfortable with three-hour intervals.

Schedules suitable for starting normal infants are given below:

<sup>13</sup> The use of the standard formula isocaloric with breast milk (see page 152) makes a further calculation of fluid requirements unnecessary; if sufficient calories are provided, the fluid intake will be adequate.



TABLE XXVII  
FOOD REQUIREMENTS AND FEEDING SCHEDULE FOR NORMAL INFANTS

Age	Calories per Day	Ounces of Formula per Day	Number of Feedings in 24 Hours	Quantity per Feeding, Ounces
1 month .....	300-500	15-25	} 5 or 6 }	3 -4½
2 months .....	400-580	20-29		3½-5
3 months .....	480-650	24-32		4 -6
4 months .....	560-700	28-35		5 -7
5 months .....	630-750	31-37	} 5 }	6 -7½
6 months .....	690-800	35- *		7 -8

\* It is not advisable to attempt to supply more than about 750 calories a day as milk formula. When more food is required, other articles should be added to the diet.

For example, an infant three months old, weighing 12 pounds (5.5 kilograms), is to be artificially fed. On the basis of 45 calories per pound (100 calories per kilogram), it is apparent that he will require approximately  $(12 \times 45 =)$  540 calories per day. With the standard formula of 20 calories per ounce,  $(\frac{540}{20} =)$  27 ounces a day will be needed. This is best prepared by taking three times the quantities taken for making 10 ounces, namely:

*To make 10 ounces*

Whole milk ..... 7 oz.  
Cane sugar ..... ½ oz.\*  
Water, up to..... 10 oz.

\* 1 level tablespoonful.

*To make 30 ounces*

Whole milk ..... 21 oz.  
Cane sugar ..... 1½ oz.†  
Water, up to..... 30 oz.

† 3 level tablespoonfuls.

The formula may be divided into 6 bottles containing 4½ ounces each (or 5 bottles containing 5½ ounces each if a night feeding is no longer required) and fed at intervals of four hours.

The first attempt at artificial feeding is somewhat of an experiment. A feeding such as is given above may not be ideal for the particular child in question. One should observe carefully the weight of the child, the appetite, the number and character of the stools and the presence of untoward digestive symptoms to see if indications arise for changing the food.

**Indications for Increasing the Food.**—If an infant appears healthy and contented and gains regularly, there is no indication for increasing his food even if he is taking somewhat less than the average caloric requirements. With some infants 75 to 80 calories per kilogram a day seems to be sufficient food. The two best indications for increasing the food are the weight curve and the presence of signs of hunger. The weight curve is important, but one should not be guided by it alone. When it is made the chief concern, there is a constant temptation to increase the food if the child is not gaining as rapidly as it is thought he should, regardless of his digestion and caloric intake. Gain in weight is seldom continuous; even healthy, breast-fed infants may have periods of a week or two, during the early months, when the weight remains stationary, with no apparent cause. During the latter part of the first year and subsequently there may be even longer periods



of stationary weight. Evidences of hunger may be easy to detect, as when an infant finishes his bottle greedily and cries for more or becomes fretful considerably before his feeding time. At other times it may be difficult to distinguish symptoms of underfeeding from those of indigestion. Crying as a result of hunger may easily be mistaken for colic. An infant may, however, cry merely because he is spoiled. Underfeeding may lead to vomiting and even to diarrhea. An infant who remains hungry after finishing his bottle may continue to suck at the nipple and thus swallow considerable air, which may cause regurgitation; at other times the restlessness associated with hunger may lead to vomiting. The so-called "starvation diarrhea," seen particularly in small infants who are underfed, consists in the frequent passage of small greenish or brownish stools composed chiefly of mucus and other secretions. The condition scarcely resembles true diarrhea except in the number of movements, for the total volume of material expelled is small. Cases of this kind respond promptly and favorably to the administration of more food. The therapeutic test should be applied if there is any suspicion of underfeeding. When underfeeding has been prolonged and has resulted in loss of weight, the appetite is as a rule lost. Such seriously underfed infants should not be placed at once on an adequate diet; the food should be gradually increased.

**Indications for Decreasing the Food.**—Overfeeding may result in loss of appetite; the infant does not finish his bottle. It may cause regurgitation after meals if too much food is taken. In the latter event one should not be too ready to conclude that the total daily feeding is too large; it may be that too large a volume is given at one time. Prolonged overfeeding beyond the demands of the appetite is likely to result in digestive disturbances and eventually in failure to gain weight. It is apparent that somewhat similar symptoms may be produced by underfeeding and overfeeding. An examination of the caloric intake will enable one to avoid gross errors in either direction; at times it is necessary to try empirically the effect of increasing or decreasing the food.

When the caloric requirements of a particular child have been established empirically, and it has been found that he will gain satisfactorily and remain healthy on, let us say, 80 or 120 calories per kilogram as the case may be, one may then make regular increases in the food, as weight is gained, to maintain the caloric intake.

**Feeding by Appetite.**—The food intake of the breast-fed child is automatically regulated by his appetite. It has been maintained that this same principle should be applied in artificial feeding and that infants should be offered an unlimited quantity of food and allowed to take as much as they desire. This practice may lead one into difficulties. Experience has shown that the more the feeding differs from what may be considered a complete and balanced diet for the infant, the less reliance can be placed upon the appetite. Thus, infants given excessive amounts of fat may become nauseated and refuse food, taking less than their nutritional requirements, while others whose diet is lacking in some essential constituent may develop ravenous appetites and be grossly overfed. Infants given concentrated feedings with inadequate water may take more food than they need in order to satisfy their thirst, and, conversely, with an overdilute food, the stomach is likely to be distended and the appetite satisfied before suffi-



cient food is taken. On this account it is advisable to use feedings which do not differ greatly from the concentration of breast milk, and which differ in composition no more than is necessary in providing for nutritional requirements. The appetite then gives valuable information.

**Common Mistakes in Infant Feeding.**—The mistake is sometimes made of changing feedings too frequently. Before changing an infant's food one should be certain that an indication exists. It is not possible to modify the food in such a way as to relieve every trivial discomfort or disturbance a child may have. Nurses are usually ready to ascribe every slight symptom to the food, particularly if they have strong opinions of their own on the subject of feeding and are not in full sympathy with the method employed. Often the cause is outside the food and even outside the digestive tract.

It is unwise to make too many changes in the feeding at one time. This does not apply to reductions of food, which must often be made suddenly in acute illness, but rather to increases of the food or the addition of new ingredients. A change in the food and in the feeding schedule should not be made at the same time, nor should more than one article of food be added at a time; otherwise, should untoward results follow, it is difficult to decide what caused them.

In deciding whether or not a change of food is beneficial one should usually allow not less than three days to elapse. To be sure, it may be self-evident within a few hours that acute indigestion has been produced and the food should then be discontinued at once. In judging improvement, however, a longer time is required. It often requires several days for the child's digestion to adapt itself to a new food, upon which he will subsequently thrive well.

There are certain definite indications for altering the food:

**Indications for Changing the Food.**—*Hot Weather.*—In hot weather the ability to digest food is impaired, particularly in young infants; moreover, less food is required. Owing to increased perspiration the need for water is greater. The indications are met by diluting the food or by making up the formula with skimmed milk instead of whole milk. The volume of the formula should be maintained and additional water given between feedings. As soon as the period of excessive heat has passed, the infant can gradually be brought back to the usual food.

*Infections.*—The part played by infections in producing digestive disturbances in infancy has only recently been appreciated. Curiously enough it does not seem possible to trace a close relation between the severity of the infection or the degree of fever and the amount of digestive disturbance produced. In one infant a common cold with comparatively little fever may produce a profound digestive disturbance, far more than may occur in another child with pneumonia and high fever. Since, however, some degree of disturbance is likely to occur in any case, it is a good precaution at the onset of any acute infection to reduce the food as indicated in the foregoing paragraph and to give additional water between meals. When it is apparent that no digestive disturbance is produced the food may be increased. A further discussion of digestive disturbances due to parenteral infections is given elsewhere.

A number of other conditions—vomiting, diarrhea, constipation, colic, failure



to gain weight, etc.—may require changes in the food or in the method of feeding. These will be discussed in subsequent chapters.

**The Use of Food Other than Milk during the First Year.**—Cod liver oil or some other form of prophylaxis against rickets should be given to all infants from the early weeks of life. This is more fully discussed in connection with rickets.

It is not necessary to give an antiscorbutic to breast-fed infants, since breast milk ordinarily contains sufficient vitamin C. Artificially fed infants who are fed on sterilized or pasteurized milk should always be given orange juice or some other antiscorbutic food from the second month onward. One may commence with a teaspoonful a day and gradually increase the quantity until an ounce a day is taken. In increasing the dose one should be guided to some extent by the reaction of the infant's bowels; for some children orange juice is distinctly laxative. It may be given between feedings or may be added to the milk after sterilization and cooling.

TABLE XXVIII  
APPROXIMATE CALORIC VALUE OF DIFFERENT FOODSTUFFS

Food	Calories per Ounce (weight)	Food	Quantity	Calories
Breast milk .....	20	Farina cooked with water...	1 tbsp.	18
Whole cow's milk.....	20	Farina cooked with milk (1-6)	1 tbsp.	28
Skimmed milk (1½% fat)...	14	Banana, 6-inch .....	1	80
Skimmed milk (fat-free)....	10	Potato, medium size .....	1	80
Evaporated milk .....	45	Spinach, strained .....	1 h'p'g tbsp.	15
Sweetened condensed milk...	100	Carrots .....	1 h'p'g tbsp.	6
Dried whole milk powder....	158	Beets .....	1 h'p'g tbsp.	14
Protein milk .....	13	Scraped beef .....	1 h'p'g tbsp.	25
Curd .....	45	Egg .....	1	80
Sugar .....	120	Zwieback .....	1 piece	30
Flour .....	100	Orange juice .....	1 ounce	15
Corn syrup .....	100	Cod liver oil .....	1 teasp.	32

APPROXIMATE MEASURES

Dried whole milk powder.....	4	level tablespoonfuls = 1 ounce by weight
Dried half-skimmed milk powder.....	8	level tablespoonfuls = 1 ounce by weight
Cane sugar .....	2	level tablespoonfuls = 1 ounce by weight
Milk sugar .....	3	level tablespoonfuls = 1 ounce by weight
Dextrimaltose .....	3	level tablespoonfuls = 1 ounce by weight
Corn syrup .....	1½	level tablespoonfuls = 1 ounce by weight
Malt soup .....	1½	level tablespoonfuls = 1 ounce by weight
Barley flour .....	3	level tablespoonfuls = 1 ounce by weight
Oat flour .....	3	level tablespoonfuls = 1 ounce by weight
Wheat flour .....	4	level tablespoonfuls = 1 ounce by weight

FEEDING DURING THE LATTER HALF OF THE FIRST YEAR

It is usually during this period that the transition to a mixed diet is effected. Cereals, vegetables, meat products, fruits and egg are gradually introduced until by the end of the first year the diet is quite a varied one. It is not possible to state an exact age at which solid food should be commenced. If it is postponed until



the latter part of the first year, nutritional anemia is likely to develop. It is quite possible to give a mixed diet to an infant a few weeks old, and this is in fact done in certain cases of idiosyncrasy to milk proteins. Under such a regimen, however, the food is far more troublesome to prepare. A further possible objection to feeding a variety of protein foods in the early months is that small quantities of unsplit proteins are likely to be absorbed during the digestive upsets which are more common at this period; this may result in hypersensitiveness to a large number of proteins. The current practice of starting solid food at about the age of six months is satisfactory and avoids both of these extremes.

New articles of diet should be introduced one at a time; two or three days should elapse before another change is made. One should always begin with a small quantity of the new food, not more than a teaspoonful; it is best given at the beginning of the meal. The feeding schedule should not be altered. As new food is added, it may be expected that the infant will take somewhat less of his old food.

**Cereals.**—These are sometimes used for young infants to thicken the feeding in the control of vomiting. Ordinarily, however, there is no advantage in starting them before the fifth or sixth month.

One should begin with the refined (white) cereals—farina, Cream of Wheat, hominy grits, ground rice. Later any of the whole-grained (brown) cereals may be introduced; these are somewhat more laxative. Cereals should be cooked with salt and water or with milk in the proportion of one part of the grain, by volume, to six or eight parts of fluid; the mixture is brought to a boil and cooked in a double boiler for one or two hours. When made with milk, the caloric value is about 28 per tablespoon; with water, about 18. Cereals should be fed with a spoon, with the addition of some of the formula. One tablespoonful may be given at first—usually at the 10 A.M. meal—and the amount increased up to three or four tablespoonfuls twice a day. As the amount of cereal in the diet is increased, the sugar in the formula may be reduced; by the ninth month all the additional carbohydrate may be supplied in the form of cereal, the sugar being entirely eliminated.

Potato may be substituted for any of the cereal foods; when it is well cooked and given mashed it is quite as digestible as other forms of starch. Spaghetti or macaroni may be similarly used. Breadstuffs are best postponed until a proper number of teeth have erupted. Crackers, toast, dried bread or zwieback are to be preferred, since these harder foods are more likely to be well chewed.

**Vegetables.**—Puréed green vegetables<sup>14</sup> may ordinarily be commenced at about the sixth or seventh month; by the ninth month they should form a substantial part of the diet. They should be well cooked by boiling or baking (rather than frying) and should be mashed or strained. If they are cooked in large amounts of water, and the water discarded their nutritional value is largely lost; such water should therefore be saved and incorporated in broths. The cellulose and often the pigment of vegetables may appear unchanged in the stools; the red pigment of beets has at times been mistaken for intestinal hemorrhage.

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<sup>14</sup> The term "green vegetables" should be understood to include not only those which are actually green, but also carrots, beets, cabbage, squash, and all those commonly included in diabetic diets as "5 or 10 per cent" vegetables.



The caloric value of vegetables is low, but they are important in preventing nutritional anemia, as has been already pointed out. Not the least important consideration in starting them early is their educational value. If such foods are postponed until the ninth or tenth month—the time when they become essential—much greater difficulty is encountered in training a child to take them than when they are commenced earlier.

**Broths.**—These should be introduced into the diet some time after the sixth month. Animal broths may be made from beef, veal, mutton or chicken; their caloric value is very low, but they contain minerals and nitrogenous extractives which are of some value. They are also useful as vehicles for other foods; vegetables and barley, rice or wheat flour may be cooked in the broth. In older children, when therapeutic starvation is employed, broths are often given, since they satisfy the appetite as well as provide fluid. As broths are introduced into the diet, the need for supplying additional water in the milk formula disappears. By the ninth month a special formula is no longer necessary; boiled whole cow's milk may be taken, the additional fluid being supplied as broth, in fruit juice, etc., or as water, and the additional carbohydrate in the form of cereals or other starchy food.

**Meat Products.**—Although beef juice, scraped or finely chopped beef, liver and chicken may be given to young infants there is seldom any indication for doing so. If vegetables and broths are given as indicated above there is no particular reason for starting meat products until about the ninth or tenth month. Beef juice<sup>15</sup> made by squeezing seared steak in a meat press is probably the most digestible form of supplying meat protein, since it requires no mastication. The precaution formerly advised—to avoid heating the beef juice to the point where the albumin coagulates—does not appear to be well founded; the coagulated protein is digested quite as readily as the unheated protein. If the meat itself is to be fed—a much more economical procedure—there is a distinct advantage in having it rare rather than well cooked, for the larger masses do not disintegrate as readily in the latter case. Rare *scraped beef* is prepared by scraping particles of meat from a piece of steak, leaving the fibrous tissue behind. Finely ground or finely chopped steak is, however, less tedious to prepare, and may be given even before the molar teeth have erupted. Liver and chicken may also be given finely chopped.

**Egg.**—Of all the foods commonly offered to infants, this is the most frequently associated with allergic reactions in the form of skin eruptions or digestive symptoms. It is therefore wise, when egg is given for the first time, to offer merely a taste. Sometimes a fraction of a gram will bring out a violent urticaria or vomiting; not infrequently this food will be instinctively rejected. It is the egg albumin to which the child is hypersensitive; on this account it is wise when giving egg for the first time to start with a small amount of egg yolk.

**Fruit.**—Young infants tolerate cooked fruit if it has been properly mashed and strained. The special value of this article of diet is its laxative effect. Bananas,

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<sup>15</sup> *Beef extracts*, once very popular, are now seldom given to infants. They do not contain appreciable amounts of protein and cannot be considered as foods; such nitrogen as they contain is in the form of extractives. These substances act like protein in having a marked specific dynamic action; moreover, additional water is required for their excretion; it does not appear that these effects are desirable. Kemmerich has shown that animals receiving nothing else died of starvation even sooner than if everything was withheld



however, are useful for their food value and in the treatment of certain specific digestive disorders; they may be given baked, boiled or raw.

**The Use of Solid Foods.**—As has already been pointed out, no hard and fast rule can be laid down in regard to the introduction of solid foods into the diet. It is convenient and usually desirable to start such foods at about the sixth month and to depend upon them to a considerable degree during the latter part of the first year. The healthy infant can digest a variety of foods, but one should not overlook the fact that until his molar teeth have erupted his capacity to chew is small indeed; mechanical subdivision of the food must be carried out in the kitchen if he is to be spared the risk of serious digestive upsets.

5th month  
better

As soon as solid foods constitute any considerable portion of the diet, the calculation of the caloric intake becomes so inaccurate that it is of little value. Appetite assumes an increasing importance in regulating the quantity of food taken. That the appetite is a satisfactory guide not only in regard to the quantity of food, but in the selection of the food itself, has been shown rather convincingly by the experiments in self-selection of diets carried out by C. M. Davis at the Mt. Sinai Hospital in Chicago. Infants weaned at seven to nine months of age were offered a variety of food and allowed to select their own diets. The choice of food was often bizarre. From time to time an infant would show a marked preference for particular foods, of which large quantities would be taken for several days; as much as seven or eight eggs or four or five bananas might be consumed at a meal. Such periods were of short duration, however, and within a few days a normal liking for the particular foodstuff would be resumed without the appearance of digestive disturbance. In spite of these temporary swings, the diet over a period of time was varied and well balanced. From the point of view of growth and gain in weight, as well as resistance to disease and freedom from symptoms of indigestion, the results were entirely satisfactory.

It is neither practical nor generally advisable to emulate these experiments in the average home. Caprices of appetite may tend to correct themselves but there would seem to be no particular advantage in indulging them. One may safely allow an infant considerable leeway in the quantity of food, provided a suitable variety is taken. In practice, the only food likely to be taken in excess by an infant in his second six months is milk; and if this tendency appears, it is advisable to restrict the amount of milk offered, so that there will be more encouragement to take other foods.

The diets given below for infants of nine months and a year of age indicate what is ordinarily fed to an average child at these periods:

\* AVERAGE DIET<sup>16</sup> FOR A NINE-MONTHS-OLD CHILD  
(Approximately 875 Calories)

- 6 A.M. Whole milk, 7 oz.
- 8 A.M. Orange juice, 1 oz.
- 10 A.M. Cereal, 3 tablespoonfuls  
Milk, 7 oz., some of this on cereal  
1 cracker or piece of toast

<sup>16</sup> Cod liver oil should be included unless other provision is made for adequate administration of vitamin D.



- 2 P.M. Vegetable or meat broth, 4 to 6 oz.  
           or scraped beef, 1 tablespoon  
           White vegetable (potato, rice, etc.), 2 tablespoonfuls  
           Green vegetable (mashed and strained), 1 or 2 tablespoonfuls  
           Milk, 4 oz. (a smaller amount if broth is given)
- 6 P.M. Same as 10 A.M.
- 10 P.M. Same as 6 A.M.

#### AVERAGE DIET FOR A ONE-YEAR-OLD CHILD

(Approximately 1000 Calories)

- 6 A.M. Milk, 7 to 8 oz.
- 10 A.M. Cereal, 4 tablespoonfuls  
           Milk, 7 to 8 oz., some of it on cereal  
           1 cracker or piece of toast
- 2 P.M. Vegetable or meat broth, 4 to 6 oz.  
           or 1 egg  
           or scraped or chopped meat, 2 tablespoonfuls  
           White vegetable (potato, rice, etc.), 2 tablespoonfuls  
           Green vegetable, 2 to 4 tablespoonfuls  
           Milk, 5 to 8 oz. (a smaller amount if broth is given)
- 6 P.M. Cereal, 4 tablespoonfuls  
           Milk, 7 to 8 oz., some of it on cereal  
           1 cracker or piece of toast  
           Cooked fruit, 1 or 2 tablespoonfuls

#### FEEDING OF HEALTHY INFANTS DURING THE SECOND YEAR

During the latter part of the first year the child should become accustomed to a variety of foods and should depend relatively less on milk. *Weaning from the bottle* is a great help in attaining this end. This should be begun by the ninth or tenth month; by the end of the first year all milk should be taken from a cup. Children who are allowed to continue with the bottle after this time usually develop the "bottle habit" and often refuse all solid food as long as it is continued. It is also advisable to teach a child to feed himself as soon as possible; this can often be done at the end of the first year, sometimes earlier.

In the second year the diet of a healthy child should consist chiefly of milk, breadstuffs, farinaceous foods, vegetables, fruit juices or cooked fruit, meat and eggs. Few children require more than a pint and a half of milk a day. The notion that there are many children who cannot take milk is a mistaken one; the usual difficulty is that too rich milk is given or that the quantity given is too large. There is, however, no actual necessity that a child at this age take milk at all, provided that his diet is properly balanced in regard to essential foodstuffs, minerals and vitamins.

An appropriate daily schedule during the second year is as follows:

- 7 to 8 A.M. Cooked cereal, 3 to 6 tablespoonfuls, with milk and a little sugar  
           Milk, 6 to 8 ounces  
           Dry bread, toast, zwieback or cracker, plain or lightly buttered
- 10 A.M. Juice of an orange (This may be given with one of the meals, instead.)



- 12-1 P.M. Meat broth, vegetable soup, ground meat or egg  
White vegetable: potato, macaroni, spaghetti, rice or hominy  
Green vegetable: peas, beans, beets, spinach, asparagus, onions, carrots, squash, etc. (mashed or strained), cooked fruit or banana  
Dried bread, zwieback or toast, lightly buttered  
A drink of milk or cracker may be given in the middle of the afternoon, provided this does not disturb the appetite at meal times.
- 6 P.M. Same as breakfast. In addition, soft-cooked egg, junket or custard or some simple dessert may be given. A white vegetable (see above) may be substituted for the cereal, and soup for the milk.

It is not possible to prescribe the exact quantities of food to be given. One must rely on the child's appetite, which is a satisfactory guide, particularly if a child feeds himself. Many healthy children occasion surprise by eating almost as much as their parents. If individual foods are refused, one should be certain that this refusal is not based on hypersensitiveness to the food in question. If it is merely a question of dislike, this may be overcome by giving this particular article of food first and withholding other food until it is eaten. The fact that the quantity of food eaten at different times is variable should occasion no concern, for appetite shows considerable variations. The attempt to standardize a child's intake is the cause of many feeding difficulties. Almost invariably the result is loss of appetite and a struggle on the part of parents to make him eat things it is believed he should have. Cajolery, bribery, and force are useless in such a situation; the child usually enjoys the struggle and the attention he receives. The wisest course is to put before the child a suitable meal and to set a time limit rather than a quantity limit. After twenty or thirty minutes the food is removed, no matter how little has been eaten. If the audience displays no interest in how little the child eats, with such a regimen it seldom requires more than a few days before the normal appetite is reestablished. Children of this age are peculiarly responsive to the emotional circumstances which attend the administration of a meal. The complaint of anorexia calls for study of the psychologic, as well as purely dietetic, factors involved.

#### FEEDING FROM THE THIRD TO THE SIXTH YEAR

With increasing age, a considerable latitude may be allowed in a child's diet. Although a healthy child may eat almost any adult food with impunity, it is wise to avoid certain foods which, when eaten in excess, may become sources of trouble; this applies to foods cooked with a great deal of grease, highly seasoned foods, such as rich salads, spices, etc., nuts, sweets, and stimulants like coffee and tea.

By the end of the second year a child should have a fairly efficient chewing apparatus. As soon as the first four molars have erupted, vegetables need no longer be put through a sieve, and meats and other foods need to be less finely divided. Some discretion must be employed here, for certain children have a tendency to bolt their food and masticate poorly. A moderate amount of undigested food in the stool is not an indication for renewed sieving and grinding, but large quantities of unaltered solids may be so. The prohibition of nuts is partly because they are likely to be poorly chewed, but chiefly because of the risk of their being aspirated.

The feeding problems which are seen at this period are quite similar to those



encountered earlier, although their manifestations may be more complex. Some degree of loss of appetite resulting in continual parental persuasion to eat is found in perhaps 50 per cent of American homes. The only satisfactory treatment—prompt removal of uneaten food and parental disregard—is all the more difficult to apply in these older children; bad feeding habits have continued longer and are more difficult to break—both in parents and in children. Many of these children are undernourished, a fact which makes disciplinary measures even more difficult to carry out in the home. When coöperation at home is not satisfactory a short stay in a hospital will accomplish the desired result. It is rare indeed for any child to resist proper food for more than three days; usually less than this is required to bring back the appetite.

Many difficulties, often attributed to the food, find their real cause in other factors in the child's life. Vomiting may be neurotic—either to attract attention or to secure some indulgence on the score of invalidism. The meal time may be prolonged in order to avoid going to bed or some unpleasant social situation. Fatigue is likely to upset the digestion, particularly in nervous, high-strung children. In such cases, additional rest during the day may produce great benefit. Many disorders of feeding and nutrition are, of course, due to organic disease.

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## CHAPTER XV

### VOMITING

Vomiting is very frequently seen in infants and young children; it may occur from a great variety of causes, some of which are trivial while others indicate serious disease.

**Causes of Vomiting in Infants.**—A distinction is sometimes made between *regurgitation*, in which a mouthful or two of food is brought up at a time with little effort or distress, and true *vomiting*, in which the stomach virtually empties itself with one or two strong contractions, assisted by the abdominal musculature. As a rule regurgitation results from minor feeding disorders, while vomiting indicates a more serious disturbance. It is not always possible, however, to draw a sharp line between regurgitation and vomiting, the difference being one of degree. The causes of regurgitation and vomiting will therefore be considered together.

*Overdistention of the Stomach.*—This may occur from the ingestion of too large a volume of food or from swallowing of air. The vomiting is not accompanied by other evidence of disease. It occurs within a few minutes after nursing, is easy and without effort. It may be excited by moving the child or making undue pressure upon the stomach. Air-swallowing is by far the most common cause of overdistention and of vomiting in general. Nursing infants may swallow air when the supply of milk is small or when the nipples are retracted. With artificially fed infants it may be the result of prolonged feeding time with the use of a slow nipple. A certain amount of air is swallowed with the food under any conditions. Regurgitation due to air-swallowing can be prevented by holding the infant upright over the shoulder for a few minutes after feeding and patting him gently on the back until belching occurs. Occasionally it is necessary to interrupt the feeding for this purpose. It may be advisable to feed the child in a sitting posture on the nurse's lap. Some infants swallow air between feedings; this habit may be encouraged by the use of pacifiers or by sucking the thumb or fingers.

Overdistention from excessive quantity of food is likely to occur if too frequent or too large feedings are given; the stomach is unable to empty itself completely between feedings.

Tight clothing is believed by some to cause vomiting; we are inclined to question its importance.

*Pyloric Stenosis.*—In pyloric stenosis and pylorospasm, which are discussed elsewhere, vomiting is a prominent symptom.

When vomiting is due to mechanical factors only, as in the foregoing instances, it is usually not associated with nausea; the infant's appetite remains good. This is in contrast to those cases of vomiting due to indigestion, whether the indigestion be due to faulty character of the food or to failure of the infant's digestive powers (as in acute infections).



*Intestinal Obstruction.*—In intestinal obstruction vomiting is rarely absent and in most cases it is persistent. The vomitus contains bile. In the newly born, persistent vomiting is almost invariably dependent on congenital obstructions of the intestine, usually in the duodenum. In malformations of the ileum, colon and rectum vomiting is less constant and appears later. In intussusception, vomiting is forcible, immediately excited by the taking of food, and is at first bilious, later becoming fecal.

*Hunger.*—Vomiting may be due to hunger; an infant, because not satisfied by his feeding, is restless and fretful and after a few minutes may vomit. The symptoms are often mistaken for those of indigestion and the food is reduced, whereas if it is increased and enough is given to satisfy the child, he is quiet and may soon fall asleep.

*Improper Food.*—The use of improper food will cause vomiting which may be severe. In infants a formula too high in fat may do this; the emptying time of the stomach is delayed; eventually the appetite is lost. The presence of tough curds in the stomach, as may be the case when raw milk is fed, may cause a certain amount of gastric distress and regurgitation. Such symptoms disappear promptly when the feeding is changed to boiled, evaporated or acidified milk, or if starch is added to the formula. It is stated by Marriott that a certain percentage of normal infants vomit when given acid milk but are able to retain sweet milk.

*Infections.*—Vomiting due to failure of the infant's digestion is seen in association with many infections. The onset of any acute febrile disturbance, such as an attack of pneumonia, is usually marked by vomiting. As a rule the vomiting does not persist throughout the disease, although it may do so. Curiously enough, infections which as a rule cause less constitutional disturbance than pneumonia frequently give rise to indigestion which persists throughout the attack and may outlast it for some time. Such may be the case with a common cold, an attack of otitis media or pyelitis. We know of a number of instances with severe vomiting and gastric peristalsis so prominent as to suggest pyloric stenosis, in which an infection of the urinary tract was found to be the cause of the symptoms. Vomiting due to indigestion often bears no definite relation to the intake of food; it may be delayed for some hours after a meal.

*Acute Peritonitis.*—Vomiting is a frequent and almost constant symptom of acute peritonitis, whether localized or general. The vomiting is usually bilious in character. There are present other evidences of abdominal infection.

*Meningitis.*—In meningitis, vomiting is rarely absent; the effects of a parenteral infection and disease of the central nervous system are combined.

*Reflex.*—Vomiting may be reflex from irritation of the pharynx. It may be excited by paroxysms of coughing, particularly in pertussis.

*Organic Nervous Disease.*—In certain organic nervous diseases, particularly meningitis, vomiting is very common. It is seldom seen in infants with brain tumors. Cerebral vomiting is usually forcible or projectile; it may have no relation to meals.

*Toxic.*—Vomiting may result from toxic causes, as in uremia. It may result from the ingestion of a variety of poisons—metallic or other chemical poisons,



spoiled food, etc. It may follow the ingestion of a food to which the patient is hypersensitive.

The vomiting of the acute digestive upset, so common in summer months, is, like the diarrhea which often accompanies it, obscure in its origin. Under the influence of fever, atmospheric heat or infections, the digestive secretions, gastric and intestinal, are inhibited. It does not seem likely that stagnation of food in the stomach leads directly to vomiting. In all probability the vomiting is caused indirectly; undigested food in the intestine is attacked by bacteria, and toxic substances produced by their action may, in addition to causing diarrhea, pass into the blood and incite vomiting. Such vomiting would therefore fall into the toxic group.

*Rumination.*—Rumination is an important cause of vomiting. Some young infants acquire the habit of regurgitating food somewhat in the manner of the ruminant animals. At any time between feedings the characteristic picture is seen: with the tongue and lower jaw brought forward and the head slightly extended, the infant makes rhythmical chewing movements, resulting in the bringing up of food, a mouthful at a time, which he then ejects without force; this may be continued until a large part of the food taken is lost. The habit of rumination commences most frequently between the second and sixth months of life; once formed it may continue for months. In extreme cases the nutrition of the infant suffers and unless it can be controlled death may result from inanition.

Rumination is easily recognized by observing an infant closely after feeding. It may be an exceedingly difficult habit to control. The use of semisolid or solid foods is sometimes effective, since these are less readily regurgitated. The feeding may be thickened with flour or cereal and fed with a spoon. In milder cases the use of thick feedings meets the situation; in other instances even these are regurgitated. Some of these infants are able to ruminate only when they can get a finger, a rung of the crib or some other object into the mouth; in such instances restraint may be effective. Other infants do not require the presence of an object in the mouth. Mechanical appliances to restrain the jaw are rather unsatisfactory because of the difficulty of keeping them in position. In our experience the most successful results have been obtained by diverting the patient; sometimes this can be done with toys, but in severe cases an attendant must be constantly at the bedside to interrupt an attempt to ruminate as soon as it is begun. In obstinate cases the method of Siegert may be tried: the cardia is closed after each feeding by a rubber balloon inflated in the lower portion of the esophagus.

Rumination is a functional neurosis without any organic basis and seems to show no predilection for neurotic families. At the same time, there is some evidence that such infants are likely to exhibit other neurotic traits in later life.

*Habit.*—Habit is a potent cause in continuing vomiting when from any cause it has occurred frequently. It appears to depend upon an exaggerated reflex irritability of the stomach or of the vomiting center.

*Diagnosis.*—In ascertaining the cause for an attack of vomiting, a careful history and physical examination are essential. One should determine (*a*) whether the quantity vomited is appreciable; (*b*) whether the material is regurgitated in small amounts or brought up all at once; (*c*) the character of the vomiting, whether forcible or not; (*d*) the character of the vomitus, whether bile-stained,



bloody or fecal; (*e*) the relation to meals; (*f*) the presence of nausea as determined by the appetite; (*g*) the presence of gastric peristalsis; and (*h*) the presence of any other evidence of disease: pain, fever, prostration, etc.

In an infant otherwise healthy, if the vomiting is not severe and is mostly regurgitation, it is probable that mechanical factors are at fault. Air-swallowing should first be considered; one should make certain that the quantity of feeding is not excessive or insufficient, and that the child is not played with after meals. The therapeutic test often indicates which of these factors is responsible. Careful observation of the patient between meals will disclose whether rumination is the cause. Vomiting accompanied by loss of appetite should suggest faulty composition of the food or a parenteral infection; such vomiting is less likely to follow the immediate ingestion of food. Severe and projectile vomiting may occur at the onset of an infectious disease, with neurological conditions or acute abdominal disease. In very young infants forcible vomiting should suggest pyloric stenosis. The presence of gastric peristalsis is strong confirmatory evidence, although mild waves are sometimes seen when indigestion is the cause of vomiting. Bile in the vomitus does not occur in pyloric obstruction; it is found in acute abdominal diseases and in most cases when vomiting is severe.

Gastric analysis is of little help in determining the cause of vomiting. By x-ray or fluoroscopy it is possible to determine whether there is gastric retention, but this can usually be decided by simpler means, by recognizing gastric peristalsis, by aspirating the stomach contents or by the occurrence of vomiting some time after feeding.

**Treatment.**—Although a small amount of regurgitation following meals is not serious and should not occasion alarm, vomiting may readily become a serious matter, interfering not only with the supply of food and fluid, but causing serious disturbance to the electrolyte and acid-base equilibrium of the body (see page 53).

The treatment of vomiting should be directed toward removal of the cause, whenever this is possible. Often, however, one must rely on symptomatic treatment, and it is sometimes astonishing what can be accomplished by this means, even if an organic lesion is present. Even though an unusual amount of air does not appear to be swallowed, this possibility must be borne in mind. The quantity of feeding given at one time may be reduced, the caloric intake being maintained by the use of more concentrated feedings. Dried milk and evaporated milk are well adapted to the preparation of concentrated feedings. The addition of more sugar to the formula is a convenient way of increasing its caloric value; but this should not be continued more than a few weeks. In many instances it is unnecessary to depart from a four-hour feeding interval, reduction of the quantity alone being sufficient; in some cases, however, better results are obtained by giving a very small amount of food every fifteen minutes or half hour. At times nothing succeeds so well as giving a thick semisolid food. This is usually well borne and is a measure of great therapeutic value. Water should be given between feedings.

A reduction in the fat intake is indicated when there is reason to suspect indigestion, as when an infection is present. The use of ice-cold feedings is sometimes successful in controlling vomiting. Gastric lavage before feedings may be



advisable when there is evidence of an overproduction of mucus; such cases are infrequent. Atropine is often used in the control of pyloric spasm; our experience has not led us to place great faith in it.

When vomiting is due to mechanical causes rather than to indigestion, refeeding is a most valuable method of maintaining nutrition. A second feeding will often be retained.

The danger of dehydration should always be borne in mind with any vomiting child. If the skin shows any evidence of loss of elasticity parenteral fluids should be given without delay. The treatment of dehydration and of the alkalosis which may result from loss of acid gastric secretions in vomiting is discussed in connection with diarrhea.

**Vomiting in Older Children.**—In older children the causes of vomiting are somewhat different. Mechanical factors play less part, nor are the effects of parenteral infections upon the gastric digestion so frequent. The most common causes of vomiting in older children are acute dietary indiscretions, organic disease of the abdomen or of the central nervous system, and various toxic causes. Among the latter should be mentioned the so-called recurrent vomiting, which is described elsewhere.

*Neurotic vomiting* is sometimes seen in older children. This may be a defense mechanism, by which the child seeks to shield himself from an unpleasant experience. Children may vomit after breakfast when they do not enjoy their school, or they may express in this fashion a protest against an unpopular nurse. At times it is a bid for attention, a sure means of becoming, for the time at least, the center of the family circle. It is an all too common mistake, when a child has a poor appetite, for the parents to coax or even force him to eat more than he is naturally inclined to do, and vomiting is often the consequence. This may apply merely to the quantity of food taken, or to certain articles of diet. Some children are able at will to vomit any food which they do not like, and yet retain other food without difficulty. One such child would tolerate large doses of quinine, to which he had no aversion, without the slightest disturbance. We have seen a number of children who, up to the third or fourth year, objected so strenuously to taking solid food that they would immediately vomit it, no matter of what variety or in how small a quantity, although fluids were taken without difficulty. Violent emotions may give rise to vomiting; people who give elaborate children's parties often discover this fact.<sup>1</sup>

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<sup>1</sup> We know of a counselor at a boy's camp whose ghost stories frequently proved so terrifying as to cause one or more of his young listeners to vomit.



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## CHAPTER XVI

### DIARRHEA

**Incidence.**—The statistics showing deaths from diarrheal diseases in New York City illustrate the marked reduction in mortality which has occurred in recent years (Fig. 20). Diarrhea no longer holds first place among the causes of infant mortality, yet it is still a problem of the foremost importance, producing a number of deaths each year and constituting the commonest ailment of

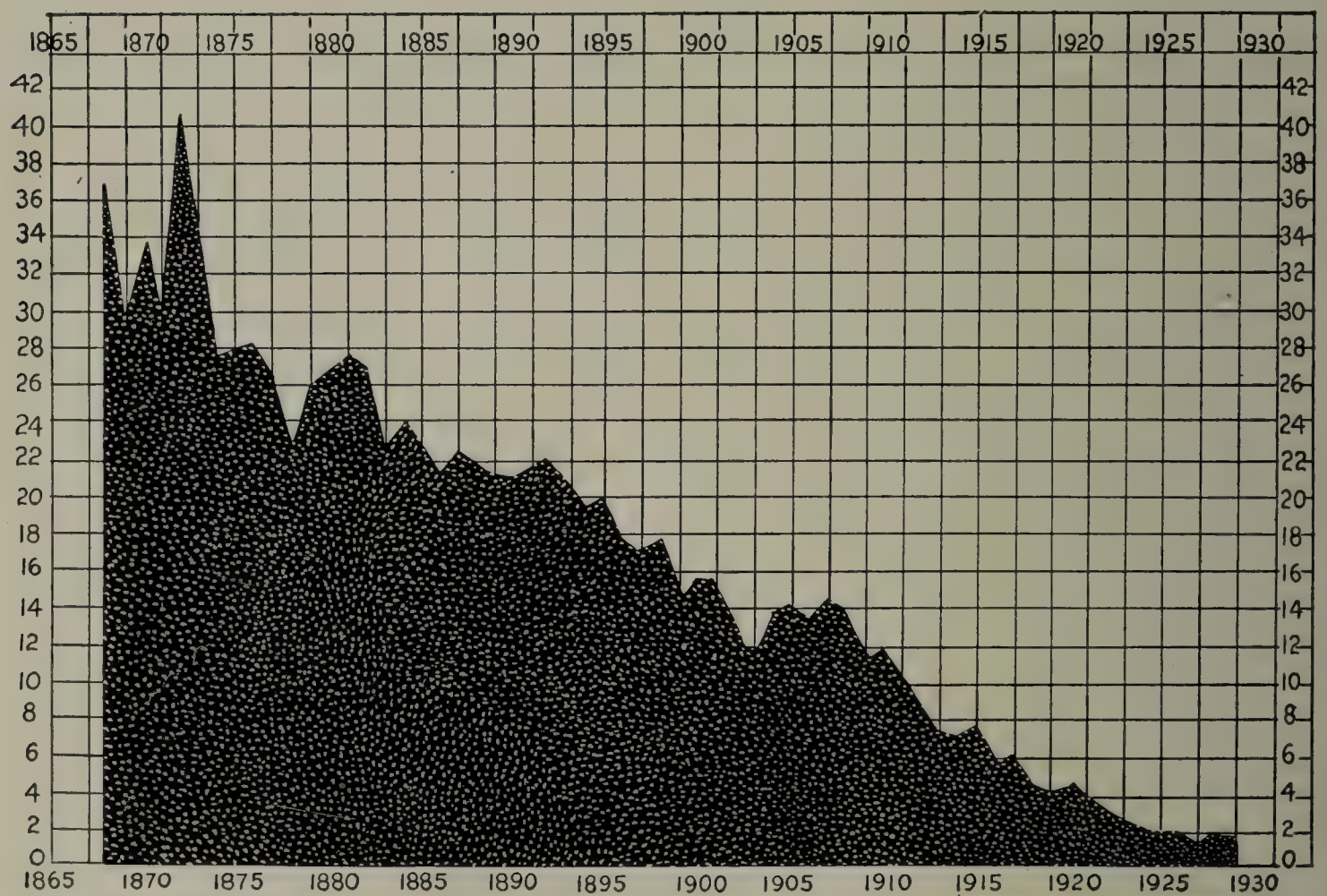


FIG. 20.—DEATHS FROM DIARRHEA IN NEW YORK CITY IN CHILDREN UNDER FIVE YEARS OF AGE, PER 1000 OF POPULATION UNDER FIVE YEARS.

infants in the summer months. Curtis reported that among 1000 infants supervised by the Boston Baby Hygiene Association (1923) diarrhea constituted 41 per cent of all disease conditions observed during July, and 81 per cent of those observed during August. This agrees well with the experience of most metropolitan dispensaries.

The published statistics unquestionably include cases of true enteric infection with bacilli of the dysentery or typhoid groups, rarely with other organisms. There can be little question, however, that the large majority belong in the group of digestive disturbances for which no specific organism can be held responsible. It is to this group of diarrheas that the present discussion will be confined. Typhoid and dysentery will be considered elsewhere.



**Etiological Considerations.**—A number of facts stand out clearly. Infants and young children are peculiarly subject to diarrhea; with increasing age this susceptibility diminishes. *Hot weather, infections and artificial feeding* are the important predisposing factors; less than 5 per cent of the severe cases occur in breast-fed infants. Diarrhea is more commonly found in cities and factory towns, and wherever conditions of cleanliness and general hygiene of the home are at fault.

The reason for the susceptibility of young infants is still obscure; it has been attributed to the fact that the secretion of acid in the gastric juice—and presumably its bactericidal power—is distinctly less than in the adult.

A number of views have been advanced to explain the baneful influence of external heat, infections and artificial feeding. The entire stress was formerly laid upon the bacteria of milk. In hot weather, when conditions of refrigeration are imperfect, milk may contain enormous numbers of organisms. The number of bacteria is not in itself of primary importance; fermented milks contain myriads of lactic acid producing organisms and are harmless enough. The symptoms are due rather to the overgrowth of proteolytic organisms—colon bacilli and staphylococci—which under these conditions are to some extent pathogenic. There can be little doubt that cleaner milk has greatly reduced the incidence of diarrhea. The susceptibility of the artificially fed infant is due primarily to imperfect milk hygiene, rather than to any chemical or biological difference between cow's milk and woman's milk.

Nevertheless, milk cannot be blamed for many of the cases of diarrhea seen at the present time. In recent years attention has been focused upon failure of the digestive secretions; in diarrhea there is a marked reduction in the gastric acidity and in the enzymes of the gastric and duodenal secretions. There is clinical and experimental evidence that either external heat, fever or infections may produce these effects, and we are inclined to regard this mechanism as important in causing diarrhea. Failure of the digestive secretions may act in two different ways: (1) Undigested food in the intestine may favor the growth of certain bacteria, or (2) the altered reaction may affect the bacterial flora. In any case, it seems probable that bacteria acting upon some constituents of the food in an abnormal way or to an abnormal extent give rise to irritating substances. According to one view it is the fermentative bacteria acting upon carbohydrates which are responsible; others maintain that proteolytic bacteria produce the untoward changes. Both of these views are supported by evidence.

It is known that in diarrhea much of the carbohydrate undergoes fermentation, with the production of the lower (volatile) fatty acids. Acids with less than 12 carbon atoms can be recovered from the stools in increased amounts; for years these have been regarded as irritants and blamed for the diarrhea. The original protein milk of Finkelstein was designed to correct this condition by reducing the intake of carbohydrates. Although it is not yet possible completely to vindicate the volatile fatty acids as a cause of diarrhea, recent observations have cast much doubt upon their harmful nature. Disastrous results do not seem to follow their oral administration. Restriction of the carbohydrate intake may diminish the production of these acids without curing diarrhea, and, conversely, a high carbo-



hydrate diet does not, as a rule, produce any noticeable aggravation of the condition.

That altered chemical conditions, particularly in the duodenum, permit abnormal bacterial growth was first shown by Moro, who observed that colon bacilli could be grown regularly from the duodenum in cases of diarrhea, whereas normally the duodenum is sterile. The suggestion that these organisms elaborate toxic products is borne out by the recent work of Plantenga and of Jordan, who have reported that filtrates from cultures of colon bacilli or certain staphylococci produce toxic symptoms when introduced by mouth, though without effect when given by rectum.

Anatomical evidence incriminating the colon bacilli has been offered by Adam and Froboese, who report the invasion of the intestinal epithelium by these organisms in cases of diarrhea.

The immediate cause of diarrhea must still be regarded as an unsettled question.

Great variations are seen in the susceptibility of individual infants to diarrhea. Many survive an attack of a severe infection like pneumonia without the slightest digestive disturbance; in others a cold may precipitate a severe attack of diarrhea. Certain infants suffer from frequent attacks of diarrhea for which no cause can be found; such cases are often classified as due to autonomic imbalance.

**Pathology.**—Usually there are no lesions in the intestines; at most there may be found some increase in mononuclear wandering cells in the mucosa. If evidences of inflammation are found, dysentery should be suspected. Rather frequently, however, tubular damage is found in the kidney; there is dilatation of the tubules with low epithelium, showing regeneration. There may be slight calcification of the epithelium. The liver cells often contain fat in the periportal region; parenchymatous degenerative changes may be found.

The *chemical pathology* of diarrhea is, however, more striking. The defective secretions of the stomach and duodenum have been mentioned above. Faulty absorption of foodstuffs is due in part to inadequate digestion and partly to the rapid peristalsis which gives little opportunity for absorption. There is also reason for believing that the ability of the intestinal epithelium to absorb is in some way impaired. Little is known as to the relative importance of these three factors.

The digestion of protein is little affected. The nitrogenous products of diarrheal stools show minor differences from those of normal stools. The child with diarrhea continues to absorb and retain nitrogen, and may do so even when moribund. Fats and carbohydrates, however, are markedly affected. Much of the ingested fat is found in the stool; moreover, the bulk of it is in the form of neutral fat, indicating that fat-splitting is defective. The absorption of carbohydrate is usually affected; residual sugar in the intestine is fermented and the acid products are found in the stools. There is evidence that the intermediate metabolism of carbohydrates is faulty. In severe diarrhea it is not uncommon to obtain a blood sugar curve of the diabetic type; glucose may appear in the urine.

The disturbance of motility interferes with the absorption of water and minerals. Holt, Courtney and Fales showed that the loss of water in diarrheal stools could exceed 600 c.c. a day. Dehydration and its concomitant changes (see



page 191) affecting the circulation and renal function play a prominent part in the pathology of diarrhea. Loss of minerals in the stools is quite as important as loss of water. All the minerals are lost in excess, but the most striking loss is found in the case of sodium, potassium and chlorine. Normally these constitute about 11 per cent of the ash of the stool; in severe diarrhea they may constitute 50 per cent. Most of this loss results from failure to reabsorb the intestinal secretions. These are alkaline in reaction; they contain more fixed base (chiefly Na) than fixed acid (chiefly Cl); acidosis results unless this loss of base is compensated for by loss of acid through some other channel. Loss of acid in vomitus may do this. In many instances the kidneys are able to prevent acidosis by excreting additional acid. Often, however, renal function is seriously impaired and little urine is excreted. In the face of dehydration, the body permits this defense against acidosis to go by the board. Dehydration would seem to be the more serious calamity.

The alterations in the blood electrolytes in diarrhea have been described elsewhere (page 53).

Schloss has called attention to *immunological changes* that may accompany diarrhea. Traces of unsplit protein can be absorbed by normal infants, but it appears that this is more likely to occur during attacks of diarrhea, and may furnish an explanation of subsequent intolerance to particular foods.

**Symptoms.**—All grades of severity are seen from mild cases, in which constitutional symptoms are not prominent, to severe forms in which marked constitutional symptoms appear; the latter are often complicated by dehydration and acidosis.

In the mild forms, from five to twelve stools a day may be passed. They are soft and watery, but do not lose their fecal character. The color tends to become greenish-yellow or even grass-green, due to the presence of biliverdin. The odor may be foul. Undigested fat curds are usually noticeable, also a moderate amount of mucus. The reaction is generally acid, particularly if a high carbohydrate diet is being fed. A moderate amount of constitutional disturbance is usually found even in mild cases. There may be some fever. The infant is fretful and irritable, with attacks of colicky pain. The appetite fails and vomiting is often present. The infant may lose weight or remain stationary. Such cases do not present a serious problem; they usually clear up in a few days. The disturbance may, however, continue and pass over into a severe form. A mild diarrhea, if it continues, may lead to marked dehydration and acidosis. The constitutional symptoms may be quite as striking as in the cases with more severe intestinal symptoms.

Severe diarrhea may develop insidiously or it may appear with great suddenness. Cases which are fulminating from the start were formerly described as *cholera infantum*. The clinical picture in these severe cases is characteristic. The temperature rises to 105° F. or more, and there is marked prostration. The child may be very restless and excitable, twisting and turning constantly; he cries continually and sleeps but little, dozing for only a few minutes at a time. Later on these symptoms may give way to general relaxation, dullness, stupor and coma. Neurological symptoms may be so prominent as to suggest organic disease of the brain. There may be delirium, convulsions, meningeal symptoms, altered reflexes



or transient pareses. *Tache cérébrale* is often pronounced. Vomiting and diarrhea may precede the nervous symptoms or may appear a few hours later. Vomiting often precedes the diarrhea. The vomitus first consists of food, then of mucus and gastric secretions; there may be regurgitation from the duodenum. Vomiting is rarely absent; it may occur only at the onset or it may persist throughout the attack even if no food is given by mouth. If vomiting subsides, it is likely to begin anew with the taking of food or drink. Diarrhea is sometimes delayed for several hours after the onset of severe constitutional symptoms. The stools are frequent, large and fluid, and may occur once or twice an hour. In the beginning they are fecal in character, and may be brown, yellow or greenish. Great bursts of flatus may be passed. The odor may be very offensive. The amount of gas passed, the colicky pain preceding the passages and the foul odor are characteristic. Later on the stools often lose all color; the offensive odor largely disappears; they then consist chiefly of mucus and serous intestinal secretions. The reaction, which at first is acid, usually becomes alkaline later. Tenesmus may be extreme. At times the sphincter may be so relaxed that small evacuations occur every few minutes.

Loss of weight under these circumstances may be precipitous; it may be as much as a pound a day. This is due to *dehydration* of the body; water and salts are lost in large quantities from the interstitial tissue spaces; the plasma volume is reduced. The results of dehydration are soon apparent. The fontanel is depressed; in extreme cases there may be overlapping of the cranial bones. The face, better perhaps than anything else, bears witness to the extent of the disorder. The eyes are sunken, the features sharpened, the angles of the mouth drawn down. An expression of anxiety spreads over the whole countenance which becomes almost hippocratic. The cornea loses its luster, becoming covered with a mucous film. The tongue and mouth are dry. The skin is dry; its elasticity is lost. When pinched up in folds, these remain for several seconds. The color of the skin is a peculiar ashen gray, it may be almost cyanotic. The abdomen is soft and sunken. Thirst may be extreme but fluid, although taken eagerly, is often vomited at once. The secretion of urine is very scanty and may cease altogether. Such cases may terminate fatally in a few days—sometimes within twenty-four hours. The nervous symptoms become more pronounced. Death usually results from circulatory failure, but there may be terminal convulsions associated with hyperpyrexia. A fatal termination may occur in cases in which the diarrhea is not extreme; a certain number progress insidiously downward in spite of treatment, until the picture of dehydration and collapse is typical.

In favorable cases the nervous symptoms, though often severe at the beginning, subside after a day or two. A very striking improvement may follow the administration of fluids. Recovery from the gastro-intestinal symptoms follows more gradually.

*Cases with Acidosis.*—In perhaps half of the infants with severe diarrhea and dehydration, there is evidence of acidosis. Nervous symptoms are almost invariably present, but the distinguishing feature is the exaggerated respiration. This does not always occur; it may be difficult to recognize in the early stages. In the characteristic “air-hunger” type of respiration, the breathing is slow and deep; it is both costal and abdominal; the accessory muscles of respiration are freely used.



Although acidosis can be successfully treated, the majority of infants with marked acidosis do not recover.

The factors producing acidosis have been discussed elsewhere (pages 50 and 53). The most important cause is doubtless excessive loss of base by the bowel. In the presence of inadequate renal function, this cannot be compensated for. Sufficient acid cannot be excreted by the kidney; moreover, the ability of the kidney to combat acidosis by producing ammonia is impaired. Renal insufficiency, although not necessarily a primary factor, plays a part in leading to acidosis. In a small percentage of cases, acidosis is apparently due to abnormal acid production in the body. Clausen has shown that in conditions of dehydration lactic acid in the blood may be greatly increased.

The nervous symptoms accompanying diarrhea have been attributed to acidosis, to dehydration and to hypothetical toxins absorbed from the gastro-intestinal tract. It seems clear that acidosis is not responsible for them; many cases with extreme prostration do not have acidosis. There can be little doubt that dehydration and its sequelae are responsible for the large majority of these manifestations. In some cases, however, such an explanation seems inadequate. Attacks are sometimes seen with severe constitutional symptoms, in which for a time there may be no diarrhea. There appears to be at the onset almost complete intestinal paralysis. Such attacks are serious and may be fatal. When one meets such a case it is difficult to escape the belief that diarrhea is essentially a protective process. Such cases are infrequent, yet they afford basis for viewing the constitutional symptoms as "alimentary intoxication."

A number of complications may beset the infant afflicted with diarrhea. Because of his run-down condition he falls an easy prey to infections of all kinds. There develops a vicious circle, for infection is likely to delay recovery from the diarrhea; at times it may cause a fatal relapse.

Sclerema is an infrequent complication of severe diarrhea. The skin and subcutaneous tissues become cold and hard. It usually begins in the thighs or buttocks but may involve the whole body, including the face. The expression is mask-like; motion of affected parts is interfered with. These cases are associated with extreme depression and are almost invariably fatal.

Cachectic purpura is not infrequently seen in severe cases of diarrhea. As a rule it carries a bad prognosis.

Prolapse of the rectum is a troublesome complication. It may persist and recur for some weeks after the diarrhea has disappeared.

Severe forms of diarrhea are often followed by prolonged periods of weeks or months in which there is marked difficulty of digestion. Diarrhea may continue no matter what food is offered. An attempt to increase the food may result only in increasing the diarrhea. Every autumn one sees a number of such patients in hospital practice. They have had one or more attacks of severe diarrhea, perhaps dysentery. They are often emaciated to an extreme degree. With careful feeding many recover; occasionally the symptoms of celiac disease develop.

**Diagnosis.**—One should not be content with the diagnosis of diarrhea without making an attempt to determine its cause, whether it is due to food, heat, a parenteral infection or unsuspected enteric disease.



Typhoid and paratyphoid may be atypical in infants and are often discovered only by stool cultures made routinely in cases of diarrhea. This is sometimes true of dysentery, but more often the presence of blood and pus in the stools makes the diagnosis of that condition clear.

A careful examination will frequently uncover a parenteral infection which may have escaped attention, usually an upper respiratory infection, otitis, sinusitis or mastoid disease.

The neurological symptoms are often most puzzling. An untrained observer is likely to err in attributing them to organic lesions. One who is familiar with the various nervous manifestations that may be associated with dehydration and diarrhea is more likely to overlook organic disease when it occurs. A lumbar puncture should always be done if there is any question.

**Prophylaxis.**—The measures to be employed in the prevention of diarrheal diseases may be inferred from what has been said about their etiology. They are:

1. Encouragement of maternal nursing
2. Clean milk
3. Education of mothers in matters of infant hygiene and artificial feeding
4. Supervision of well babies by physicians

The application of these measures on an extended scale has always resulted in a marked reduction in the mortality from diarrhea in any community.

It is no doubt preferable to move children to cooler climates in the hot summer months; however, it is often impracticable to do this. The physician who is responsible for the care of artificially fed infants during hot weather should make certain (1) that the strictest caution is employed to prevent infection; (2) that all milk is carefully sterilized; (3) that excessive clothing is eliminated; (4) that additional water is given between feedings; (5) that overfeeding is avoided. Infants are more likely at such times to suffer from thirst or from heat than from hunger. On particularly hot days it is advisable to reduce each feeding by one-third, making up the volume with water. It is probably wise to avoid formulas with high fat.

**Treatment.**—Diarrhea in the breast-fed infant is not a serious problem. Its management has already been discussed (page 139). In the artificially fed infant a mild diarrhea presents no great difficulty. A brief period of starvation with gradual return to normal diet usually meets the situation. The tolerance for food is often promptly regained.

A severe case of diarrhea is an acute medical emergency. One should not temporize when symptoms of dehydration or acidosis are present. These must be treated without delay; the infant's caloric requirements can for the moment be neglected.

The problem in combating dehydration is to replace the water and electrolyte which have been lost from the tissue spaces and the blood plasma. The chief mineral constituents of plasma are sodium and chlorine, and replacement of these two minerals is of prime importance. The electrolyte loss in dehydration is not confined to sodium and chlorine. Balance experiments have shown that potassium, phosphorus and other minerals may be lost in large quantities; these are derived



almost entirely from the body cells, not from the interstitial fluids. In states of starvation the body must burn its own cells; their mineral constituents are then a pure waste and are excreted. There would seem to be little reason for replacing these elements. Although Ringer's and other solutions designed to imitate the electrolytes of blood plasma have been recommended at times for the treatment of dehydration, as a matter of practical experience a physiological solution of NaCl (0.90 per cent) has proved quite as effective.

The introduction of fluid by mouth should always be attempted, but the amount that can be so taken is often limited by the presence of vomiting. The stomach will sometimes tolerate fluid given by the nasal drip method when larger quantities are vomited. For oral administration half-normal saline solution (one level teaspoonful to a quart) should be employed. Enemata are seldom well retained, and in most severe cases parenteral fluid administration must be resorted to. Normal saline solution may be given intravenously, intraperitoneally or by hypodermoclysis. These procedures are discussed in detail elsewhere (page 62). The intraperitoneal route has the advantage that absorption is more rapid than from subcutaneous infusions, but it cannot be used when there is abdominal distention. From 150 to 300 c.c. may be given to an infant; this amount is usually absorbed in four or five hours from the peritoneum, more slowly if given by clysis. Such infusions may be given twice daily; they should be continued until fluid can be given in adequate quantities by mouth.

In extreme cases, intravenous infusions are indicated. The response to such therapy is often immediate, but is very temporary unless the infusion is continued. Fortunately, the recent advances in the technic of continuous intravenous therapy have made this procedure an altogether practical one.

The treatment of acidosis has provoked much discussion. In the past, when attention was focused on the reaction of the plasma rather than on the underlying disturbance of mineral metabolism, the results were far from satisfactory. The reaction of the blood may be restored by the use of sodium bicarbonate intravenously, but unless chemical studies of the blood are made it is difficult to regulate the dose; an excess of bicarbonate is objectionable in that it leads to alkalosis and tetany. Hartmann has suggested the use of a solution containing lactate to avoid this difficulty. Gradual oxidation converts the lactate into bicarbonate, giving a more prolonged effect and avoiding the danger of alkalosis. This is open to one objection. Certain dehydrated children have such poor circulation that lactic acid is not oxidized and accumulates in the blood; to give more lactate under these circumstances seems illogical. Hartmann states that even in such cases the blood lactic acid usually falls after lactate is given, but this does not invariably occur. Probably the most satisfactory treatment is that directed toward prompt restoration of renal secretion. The kidney, when functioning normally, can secrete acid or basic radicals as needed. Gamble has shown that if sodium chloride is administered, either sodium or chlorine may be retained by the body and the other excreted in the urine. By this means, either acidosis or alkalosis is promptly remedied. The effect is permanent as long as the kidneys are functioning and sufficient saline is supplied. The treatment does not require control by blood chemical determinations. An effective means of restoring renal secretion is by the use of a hyper-



tonic solution of glucose intravenously. From 50 to 60 c.c. of a 10 per cent solution may be slowly injected; the rate should not exceed 10 c.c. a minute. This tends to produce a hydremia of the blood, and will usually cause a prompt resumption of urine secretion. This treatment should always be accompanied by saline or Ringer's solution given intraperitoneally or by hypodermoclysis. It has been shown that more rapid absorption of an infusion occurs after a hypertonic solution has been given intravenously. After the flow of urine has been freely restored, saline infusions should be continued as long as dehydration persists or until such fluids can be taken by mouth. It may be necessary to continue with the administration of parenteral fluids for many days. Infusions of glucose are sometimes given alternately with saline, in the hope that some energy may be obtained in this way. Their food value is almost negligible. Often the blood sugar is high to start with, and the excess of glucose is merely excreted in the urine. Occasionally a child is met with who, under these circumstances, responds well to the administration of insulin with glucose; this is, however, distinctly unusual.

*Diet.*—Starvation is a logical procedure in the treatment of diarrhea; it relieves the intestine from the burden of food which it cannot digest; presumably it also deprives the toxin-forming bacteria of their food. Most important of all, a period of starvation often causes striking clinical improvement. Complete starvation should rarely be continued for more than twenty-four hours; after this the food should be gradually increased up to maintenance requirements. In increasing the food one must be guided by the child's ability to digest, and by his ability to survive further semistarvation. The physician is faced with the dilemma, on the one hand, of giving the child food which he cannot digest and, on the other, of starving him unduly. If the infant is well nourished, there is no particular hurry about increasing his food; one may take ten days or more before a maintenance diet is reached. Many children are, however, so badly nourished at the start that they cannot bear prolonged semistarvation. With such it seems best to restore them to a maintenance diet in four or five days.

One gets a clinical impression, which awaits more definite proof, that glucose is particularly beneficial in cases where intoxication is an outstanding feature. Under these circumstances, one may give additional glucose by mouth, the quantity of milk being increased more gradually.

It is our conviction that sour milks have some definite advantage in feeding these children, though the difference between these and sweet milk is not as great as has been supposed. One may use protein milk with added sugar, fermented whole milk, acidified milk or buttermilk; there seems to be little choice between them. Protein milk may improve the appearance of the stools, which soon take on the characteristic "soapy" appearance, but it is doubtful if there is any corresponding benefit to the child. It is wise to continue the use of acid milks for some weeks into convalescence.

*Hygienic Treatment.*—An attack of diarrhea should always occasion suspicion that there has been an error in hygiene or feeding. The previous care, feeding and possible infectious contacts of the infant should be investigated. By this means it is often possible to prevent further attacks.

Infants with diarrhea should be isolated. There is always the possibility that



the symptoms may be due to an enteric infection. Other children and adults should be protected against this. For the infant's own benefit isolation is desirable to prevent any infections which might cause an exacerbation of his digestive disturbance.

The question often arises whether a child should be removed to a cooler climate. With an acutely ill child it is unwise to attempt this, but with convalescence such a change may be desirable.

*Medicinal Treatment.*—Drugs play a minor part in the treatment of diarrhea. The practice of purging, once universal, has largely been discontinued. It adds to the discomfort of the patient and to the severity of the dehydration. It is seldom that indications for catharsis arise; if there is distention, fever and foul stools which are not very numerous, a dose of castor oil may be given; it should not be repeated. If the diarrhea is profuse, cathartics should not be employed; the intestine requires no aid in expelling its contents.

Intestinal antiseptics have fallen into disrepute; it is doubtful whether they are of the slightest value. Bismuth preparations may have some effect on the stools in mild cases; in severe ones they accomplish nothing. They usually blacken the stools. Our experience leads us to place little reliance on astringents.

Opium may be required in some cases; it is, however, capable of doing harm and should not be used routinely. It is indicated when the movements are very frequent and tenesmus is marked. It should not be given until one feels certain that the gastro-intestinal tract has been satisfactorily emptied. For an average infant of six months 10 minims of paregoric may be used, to be repeated every one, two or four hours, according to the effect produced. In some cases morphine hypodermically is preferable.

Not the least important part in the treatment of diarrhea is the *treatment of the parenteral infection*, which so often is responsible for it.

**Diarrhea in Older Children.**—After the second year children seem to acquire a tolerance to heat, infections and the various factors which precipitate diarrhea in young infants. Diarrhea when it occurs in older children, if not due to dysentery or some other enteric infection, is usually caused by a dietary indiscretion.

The symptoms are seldom severe or prolonged. Vomiting may occur at the onset but does not persist. Nervous symptoms are decidedly unusual.

There may be mild fever, coated tongue, anorexia, and abdominal pain. Urticarial eruptions are sometimes seen.

Treatment with parenteral fluids is seldom required. If the history of dietary indiscretion is definite, or if symptoms have developed in a number of individuals who have eaten the same food, a purgative should be given. The application of heat to the abdomen helps to relieve abdominal pain. Food should be withheld for twenty-four hours, only liquids being given by mouth. It is well to begin with broths rather than milk. Refined cereals, toast or crackers, potato, egg, and lastly foods containing residue may then be added. Fruit juices may be poorly tolerated.



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## CHAPTER XVII

### DEHYDRATION

Dehydration may be defined as a reduction of the interstitial tissue fluids of the body. It is usually accompanied by a reduction in the volume of blood plasma; it may be accompanied by loss of fluid from the interior of the cells themselves. Dehydration occurs whenever the organism is unable to obtain or retain sufficient water for its needs. Vomiting and diarrhea are the common causes; rarely it results from failure to ingest sufficient water. It may follow severe hemorrhage or conditions in which large amounts of fluid are sidetracked as exudates. It may occur with extensive burns and other skin lesions.

Dehydration should not be regarded as a simple water deficiency; it is a deficiency of water and minerals (chiefly Na and Cl) of which the plasma and interstitial fluids are composed. Loss of water alone or of salt alone will, however, lead to dehydration; both are necessary to maintain the tonicity of the body fluids, and a loss of one leads to a prompt excretion of the other. A salt-poor diet is quickly followed by a negative water balance, and *vice versa*, with inadequate water intake the body loses salt.

The accompanying diagram, taken from Gamble, illustrates the paths by which water enters and leaves the body (Fig. 21). The interstitial fluid forms a more or less elastic reservoir, which is in relation with the blood plasma on the one hand and with the intracellular tissue fluids on the other. When water and minerals are lost by the body this loss is felt first of all by the blood plasma.

Plasma fluid and electrolyte are, however, promptly replaced from the interstitial fluid reservoir. Little reduction of the volume of vascular fluid occurs until the process has continued and the interstitial reservoir has begun to fail. It would

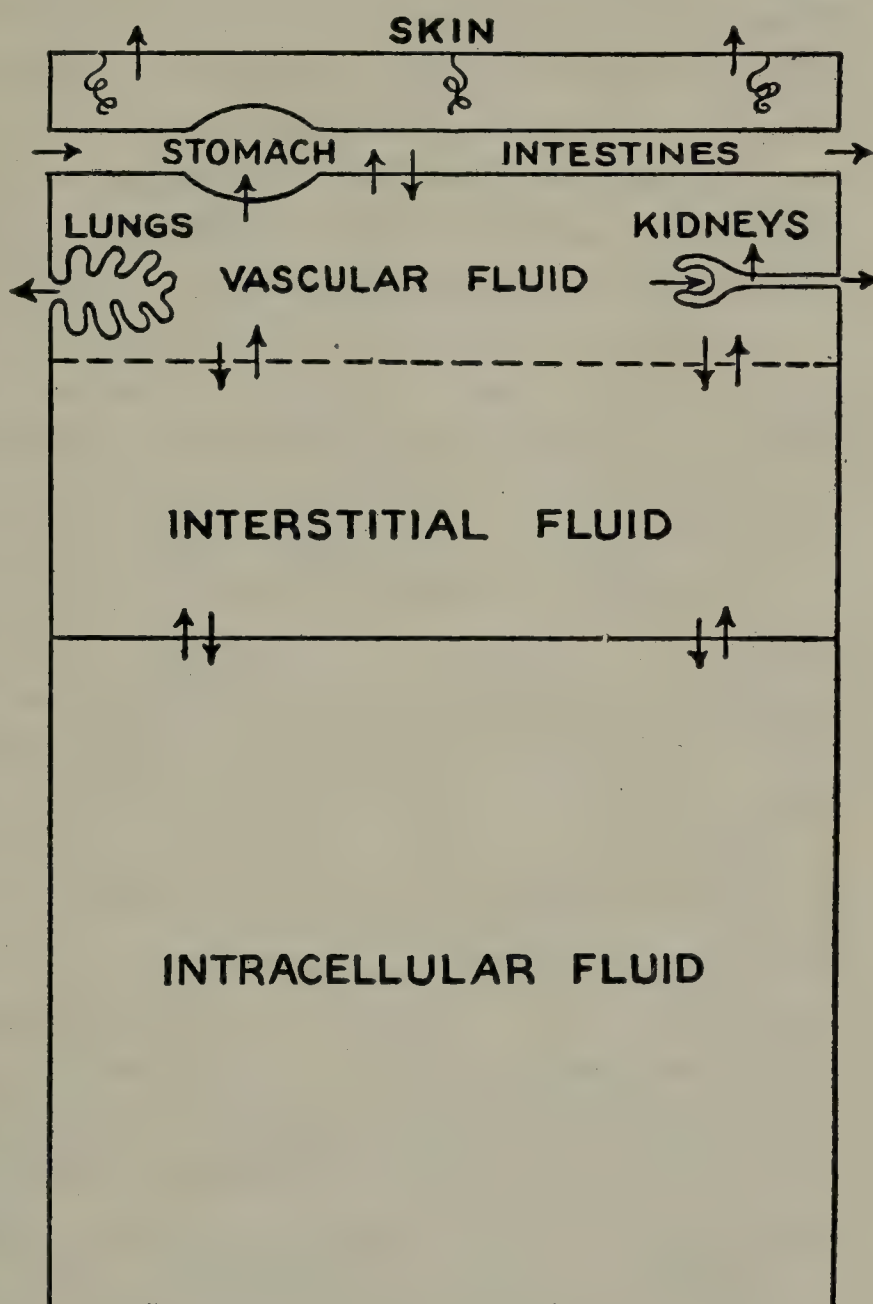


FIG. 21.—WATER EXCHANGE IN THE BODY.  
(Adapted from Gamble, *N. Eng. J. Med.*, 1929,  
201: 909.)



appear from the diagram that the intracellular fluid of the various tissues provided an even greater reservoir from which plasma and interstitial fluid could be replenished in case of need. Such is not the case, however; although the cells may lose fluid in dehydration and cell death may occur, this fluid can play little part in replacing interstitial and plasma fluid because of striking differences in its inorganic content. The minerals of plasma and interstitial tissue fluid are chiefly sodium and chlorine, while those of intracellular fluid are chiefly potassium and phosphorus.

**Effects of Dehydration.**—Although loss of interstitial tissue fluids produces conspicuous changes, particularly in the skin, the serious consequences of dehydration are due to cellular changes and to the decrease in plasma volume which occurs in severe cases.

Diminished plasma volume causes an increase in the viscosity of the blood; the proteins of the plasma are likely to be increased; the red cells are relatively more abundant and there may be marked polycythemia with hemoglobin values above 100 per cent. As the viscosity rises, the volume flow of blood through the tissues decreases and the respiratory function of the blood is improperly carried out. Acid metabolic products are not well removed, and there tends to occur what Rous has termed an "outlying acidosis" of the tissues. Physiological oxidations suffer and lactic acid tends to accumulate in the blood. For reasons not well understood the blood sugar sometimes rises and there may be glycosuria.

An increase in the nonprotein nitrogen of the blood bears witness to impaired renal function; there may be retention of phosphate and sulphate as well. In the attempt to conserve fluid, the volume of urine is diminished as dehydration advances; often only a small amount is secreted which is practically free from Na and Cl. There may be complete suppression of urine.

As explained elsewhere (page 53), the acid-base equilibrium may be affected. Failure of the kidneys to excrete acids and the accumulation of lactic acid tends to produce an acidosis. Loss of the alkaline intestinal secretions (as in diarrhea) leads to acidosis, while loss of the acid gastric secretions (as in vomiting) leads to alkalosis. The final result will depend upon which of these factors predominates.

**Symptoms.**—The clinical picture of dehydration has already been described in connection with diarrhea (page 183). The dry skin and mucous membranes, the ashen gray color, the mental torpor, the sunken eyes, contracted, wrinkled facies, the sunken fontanel and the retracted abdomen form a characteristic picture. Thirst may be extreme or fluid may be refused. There may be marked meningeal symptoms. Loss of weight is always striking; it may be precipitous. Respiration may reflect the acid-base disturbance. The pulse is usually feeble; death when it occurs results from circulatory failure. One of the most striking manifestations of dehydration is fever. Dehydration fever in the newly born has been described elsewhere. In older infants it may result from the use of too concentrated a food. Such instances were in the past often erroneously attributed to the excess of some dietary constituent, rather than to the relatively low water intake. Numerous reports of "salt fever," "protein fever," etc., are to be found in the literature, in which unquestionably lack of water was responsible. Fever is more likely to occur in the acute cases of dehydration. When the condition develops insidiously it may be accompanied by a subnormal temperature.



**Treatment.**—Dehydration calls for prompt and energetic treatment. The parenteral administration of fluids is essential in all but the mildest cases. The bulk of this fluid should consist of normal saline, for it must be remembered that electrolytes as well as water have been lost. Disturbances in acid-base equilibrium are quickly overcome, as a rule, by saline alone if proper diuresis is reestablished, the excess of acid or base being excreted by the kidney. It has been claimed that hypertonic glucose intravenously accomplishes this somewhat more rapidly than other agents. It should, however, be accompanied by saline subcutaneously or intraperitoneally. The continued use of glucose is sometimes recommended even after diuresis is established in the hope of supplying a few calories. Little energy can be supplied by this means, however, and the bulk of the glucose is excreted in the urine. Transfusions are sometimes of importance in enabling the patient to maintain improvement. Every effort should of course be made to encourage the intake of fluids by mouth. If a subnormal temperature is present, external heat may be necessary. Drugs are of no avail except as temporary stimulants.

The immediate results in the treatment of dehydration are often most gratifying. The symptoms may disappear almost miraculously within twenty-four hours. The milder cases will respond well to intraperitoneal or subcutaneous fluids, but in extreme dehydration the circulation is so poor that fluid so given is not rapidly absorbed. Intravenous therapy should then be given without delay.

The prognosis in cases of dehydration is of course dependent on its cause. Dehydration, if properly treated, is not a cause of death. However, in many cases it accompanies serious disorders of digestion, which may not yield to treatment. Such cases may die of inanition, even though their fluid and electrolyte requirements are maintained.

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## CHAPTER XVIII

### MALNUTRITION

#### MALNUTRITION IN INFANTS (MARASMUS)

**Etiology.**—An infant who fails to gain weight is not necessarily abnormal. Gain in weight is seldom continuous; during the first six months it is not uncommon to meet periods of one or two weeks in which the weight is stationary. Toward the latter part of the first year, periods as long as a month may be encountered in which no gain is made. These are often preceded or followed by unusually rapid gain in weight. The retention of water, minerals and foodstuffs and the construction of new tissue do not proceed with perfect regularity even in the normal individual.

A stationary weight for longer periods than those mentioned or, more particularly, loss of weight should always receive prompt attention. Even in the absence of acute digestive disturbances, it indicates that something is wrong with the child's nutrition. Unless this is remedied, it may progress until a state of malnutrition has been reached, from which recovery is difficult.

Malnutrition may develop rapidly or insidiously; all degrees of severity are seen. The extreme cases form a very striking and characteristic clinical picture, to which the terms *marasmus*, *athrepsia* and *infantile atrophy* have been applied.

Infants with marasmus represent the failures of artificial feeding. The condition is rare among the breast-fed; it is not very often seen in the country or in private practice. Marasmus occurs particularly among the hospital and dispensary population of big cities, for among the poor and ignorant artificial feeding is likely to be badly done.

The history in severe cases is strikingly uniform. The following is the story most frequently told. "At birth the baby was plump and well nourished and continued to thrive for a month or six weeks while the mother was nursing him; at the end of that period circumstances made weaning necessary. From that time on the child ceased to thrive. He began to lose weight and strength, at first slowly, then rapidly, in spite of the fact that every known infant food was tried." As a last resort the child, wasted to a skeleton, is brought to the hospital.

Marasmus is seen with great frequency in foundling asylums and similar institutions for young infants. The cause here is not necessarily the feeding, but rather the overcrowding, the frequent infections and the lack of individual care which these inmates receive. The food itself may be beyond criticism, but it is often given in an improper manner. The children are often overclothed and given little opportunity to move or exercise. They acquire one infection after another: colds, otitis media, pyelitis, contagious diseases, etc. Many who are plump and healthy on admission lose little by little until at the end of a few months they



become wasted to skeletons and die of some mild infection. Fortunately such conditions are steadily becoming less frequent. In many communities orphan children are now boarded out in families rather than herded together in large institutions.

The important causes of malnutrition in infants are therefore bad feeding, poor hygiene and infections. The commonest mistake is to give too little food. Underfeeding may occur in breast-fed infants, but is more often found in those artificially fed. Minor digestive disturbances, which may have little significance, are often erroneously regarded as evidence of intolerance to food; the intake is then reduced until less than the caloric requirements are given. At first the infant's appetite may give evidence of underfeeding, but eventually this may be lost. A vicious circle is started, for with lack of food the tolerance for food is gradually impaired and the condition eventually may become what it was in the first instance erroneously thought to be. Flagrant errors in underfeeding are sometimes seen, which result in rapid loss of weight. An infant may have been given nothing but barley water for weeks at a time. We once saw a child who had been fed exclusively on milk of magnesia in the belief that this was a food. In other instances the food may be deficient in protein, mineral or vitamin requirements, and these deficiency syndromes may be added to the picture of malnutrition. The intake of water may be inadequate. The food may be indigestible, such as solid foods which are not properly subdivided and from which the infant cannot derive sufficient nourishment. An over-rich food, resulting in loss of appetite, may be the root of the difficulty. In rare instances hypersensitiveness to a given food may be responsible for failure to thrive. More frequently the error lies in the technic of feeding—a small nipple, air-swallowing, etc. An all too common mistake is to change the feeding too frequently and too suddenly. The digestive secretions are in large measure influenced by the character of the diet. It requires several days for them to adapt themselves to a change of food; during this period digestion may be inadequate. For this reason changes of food should be gradual and no more frequent than necessary.

The influence of bad hygiene is difficult to estimate. Such factors may well be important in lowering resistance to infections. Curiously enough the debilitating chronic diseases so often responsible for malnutrition in adults—tuberculosis, syphilis and neoplasms—play a relatively small part in malnutrition of infancy. The acute and often minor infections of the respiratory tract, the ears and the urinary tract are of far greater importance.

Malnutrition shows a seasonal incidence in young infants. It is more frequent in the summer and autumn months, which suggests that atmospheric heat with its depressing effect upon the digestive secretions is a contributing factor, just as is the case with diarrhea and other disorders of digestion.

Finally, it must be admitted that it is not always possible to find why certain infants fail to thrive. Such instances are regarded as due to some congenital weakness of constitution, a concept which is far from satisfactory. A considerable number of premature infants fall into this group.

**Pathology.**—Infants dying of marasmus show no characteristic lesions and arouse little interest on the part of pathologists. Occasionally some unsuspected chronic infection, such as tuberculosis, is discovered; fatty infiltration of the liver



is sometimes found; it does not appear to be more frequent than in infants dying from other diseases. There is marked atrophy of the subcutaneous fat and of the muscles. The body proportions may be strikingly altered. Growth in length may have continued with little impairment even in the face of steady loss of weight; the body consequently appears long and thin. Growth of the brain and hence of the skull is not, as a rule, retarded; the child's head may then have the appearance of being too large for the rest of the body.

Far more striking than the anatomical changes are the evidences of morbid physiology which can be ascertained during life. The suppression of the digestive secretions has already been mentioned, although this is usually not so pronounced when symptoms of indigestion are absent. In many uncomplicated cases of malnutrition it is surprising how little evidence of impaired digestion and absorption of fat and carbohydrate can be demonstrated. The evidences of starvation dominate the picture. Combustion of the body tissue is reflected in marked negative balances of nitrogen and minerals. Inadequate intake of water may lead to dehydration and all its secondary effects upon the circulation and renal secretion. An inadequate intake of protein may be reflected in the blood, the protein of which may fall below 5 per cent. Vitamin deficiency diseases are commonly encountered.

Malnutrition causes a vicious circle. Weight is lost because the nutrition requirements are not met, yet because of the growth in length and in surface area of the body and the loss of its subcutaneous protection of fat, the basal metabolic requirements become steadily higher. The energy requirement of a malnourished infant may be almost 100 per cent above the normal average, when computed on a basis of body weight.

**Symptoms.**—The malnourished infant may continue to lose weight until a condition of extreme wasting is seen; there may then be little change for several

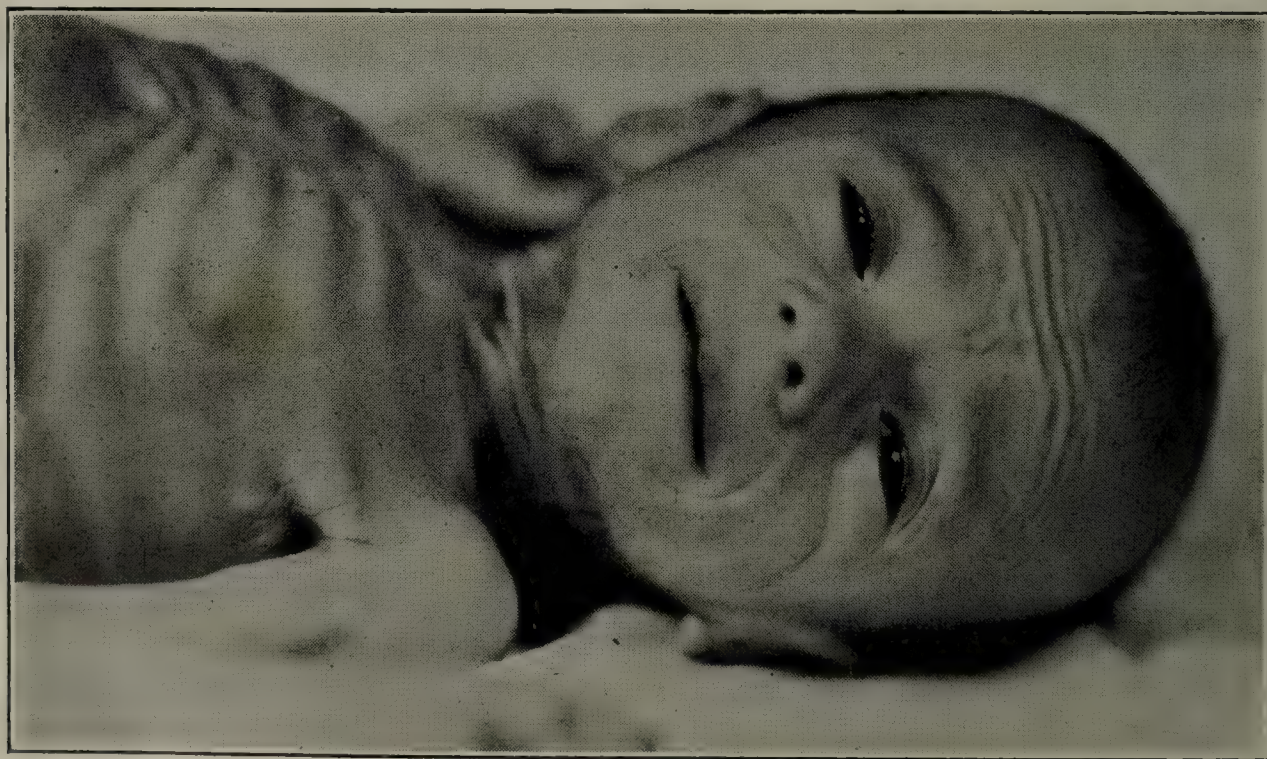


FIG. 22.—MARASMUS IN PATIENT SEVEN MONTHS OF AGE.  
Weight 2950 grams (6 pounds, 10 ounces).

weeks. When marasmus is advanced, the picture is quite characteristic. The infant has an aged look, the drawn features, wrinkled skin and hollow temples giving him



the appearance of a toothless old man. The atrophy of subcutaneous fat and of the muscles makes the skin hang in loose folds, particularly in the extremities. The bones and joints are prominent; the hands resemble bird claws, the legs are like drumsticks. In young infants, two fat depots in the cheeks—the so-called *sucking pads*—survive the general atrophy, apparently because the fat in this region has a different composition. The skin takes on a peculiar leaden pallor. Owing to the disappearance of fat, the lymph nodes and veins are apt to appear prominent. The abdomen is scaphoid or distended. The temperature is often subnormal. The activity of these infants is reduced; their disposition is usually petulant. Appetite may be preserved but is more often lost. Vomiting and diarrhea are readily provoked.

*Complications.*—Nutritional anemia is not uncommon and accidental heart murmurs are likely to be heard. As has been mentioned, infants with marasmus commonly exhibit the effects of lack of one or more dietary factors. Rickets or scurvy may be found; rachitic changes are not striking because of the interference with growth. Some observers attribute the failure of growth and loss of appetite to lack of one of the B group of vitamins. Keratomalacia is not very rare, and may lead to perforation of the cornea.

A not infrequent symptom is general edema. Attention may be called to this first of all by sudden unexpected gain in weight; the edema may increase until the entire body is water-logged; the serous cavities, however, are seldom involved. The mechanism of nutritional edema is discussed elsewhere.

A peculiar rigidity of the muscles sometimes occurs in marasmus, especially in the legs and neck. The muscles are contracted and hard; it is difficult to extend the extremities and there may be marked opisthotonos.

Cachectic purpura may be observed in infants in the late stages of marasmus. Small petechiae or large ecchymoses develop upon the abdomen, thorax, the back and neck especially. This condition is not accompanied by any reduction in blood platelets. Negative blood cultures are usually obtained. It is of bad prognostic import; few children who develop this symptom recover.

The infant with marasmus falls an easy prey to infections of all kinds; respiratory, otitic and urinary infections are the most common. Thrush and bed sores are frequent complications: the latter usually appear upon the occiput but may be seen on the sacrum or the heels. Infections make the treatment difficult and the prognosis frequently bad. All the gain of weeks and sometimes more may be lost as the result of an attack of otitis.

**Treatment.**—The most important treatment relates to prophylaxis. Maternal nursing should be encouraged by all means, especially among the poor. If artificial feeding must be relied on, it must be done under intelligent guidance. General hygienic measures, particularly the prevention of infections, are perhaps the most important means of control.

Severe forms of marasmus can be prevented by prompt recognition and treatment at an early stage. If an infant does not gain regularly, or if he begins to lose weight, the cause should be sought at once. The caloric intake should be investigated—in the case of the breast-fed infant, by weighing before and after nursing. The nature of the food and the technic of feeding should then be inquired into.



Above all a search should be made for infections which may have escaped notice. A common mistake to be avoided is that of changing the formula frequently, because of minor digestive symptoms which may be of no importance. By a careful study it is usually possible to discover the difficulty and to apply an appropriate remedy. Measures to be employed in the face of dehydration, diarrhea or vomiting are discussed elsewhere. There exists the further problem of the infant who in the absence of these symptoms refuses to thrive and gain weight. If the temperature is subnormal, artificial heat must of course be supplied.

In feeding such infants, breast milk is desirable if it can be obtained. If it is not available, some form of acid milk, evaporated milk or dried milk may be employed. Even more important than the type of feeding used is the necessity for giving sufficient calories. Markedly undernourished infants may require 200 calories per kilogram (almost 100 calories per pound) and will fail to gain weight unless this is given. If there has been prolonged underfeeding it is not advisable to feed such large quantities all at once. It is better to advance cautiously during the course of ten days to two weeks. The stomach often will not tolerate the additional quantity required for these high caloric diets if feedings of the usual type are used. It therefore becomes imperative to employ concentrated feedings by increasing the sugar content of the milk, by adding starch in some form, or by using evaporated or dried milk with a reduced quantity of water in the formula. In general the most successful high caloric feedings are those with high carbohydrates. They should not, however, be continued for more than a few weeks. Nor should they be used when there is reason to suspect that the diet has been deficient in protein, as when nutritional edema is present. In such instances one should employ a balanced formula.

Special symptoms such as keratomalacia or other vitamin deficiencies should be given appropriate treatment. Administration of vitamin B preparations has been enthusiastically advocated for all such cases. We are not convinced of their value; however, there is no objection to their use.

Occasionally, lack of appetite is successfully treated by injections of insulin. A small dose of one to two units once or twice a day at the time of feeding may produce dramatic results.

When the infant does not tolerate sufficient food to supply his caloric requirements, temporary expedients may be of great value. Transfusion is at times a life-saving procedure. It may be necessary to give transfusions once or twice a week for a prolonged period. The administration of glucose parenterally may supply a few additional calories. In occasional instances we have seen striking improvement follow the administration of glucose and insulin or of insulin alone. A protocol of such a case is given below.<sup>1</sup> In the majority of instances, however, there seems to

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<sup>1</sup> J. N. (#60595) was admitted to the Harriet Lane Home at the age of a year weighing 9.4 lbs. He had been a premature infant and had suffered from underfeeding and from various infections. On admission he showed chronic rhinopharyngitis, bronchitis and otitis media; these infections continued with little change during the period covered by the accompanying chart (Fig. 23). On the regular hospital diet the patient made little progress, and at the end of a month his weight had increased to only 10.3 lbs. The administration of 6 units of insulin a day caused a rapid gain in weight. When additional sugar was given with the insulin the gain in weight was even more dramatic. The rapid gain continued only as long as insulin was given. Subsequently (not shown on the chart), when the infection had subsided, a rapid rate of gain continued without insulin.

There was no evidence of diabetes in this patient. A glucose tolerance test, done at the point marked "X" on the chart, showed a return of the blood sugar to the normal fasting level within two hours.



be no advantage in giving insulin except in the small quantities required to stimulate the appetite.

In severe cases of marasmus the outlook is always doubtful. Intelligently treated, many do very well; perhaps the great majority would recover were it not

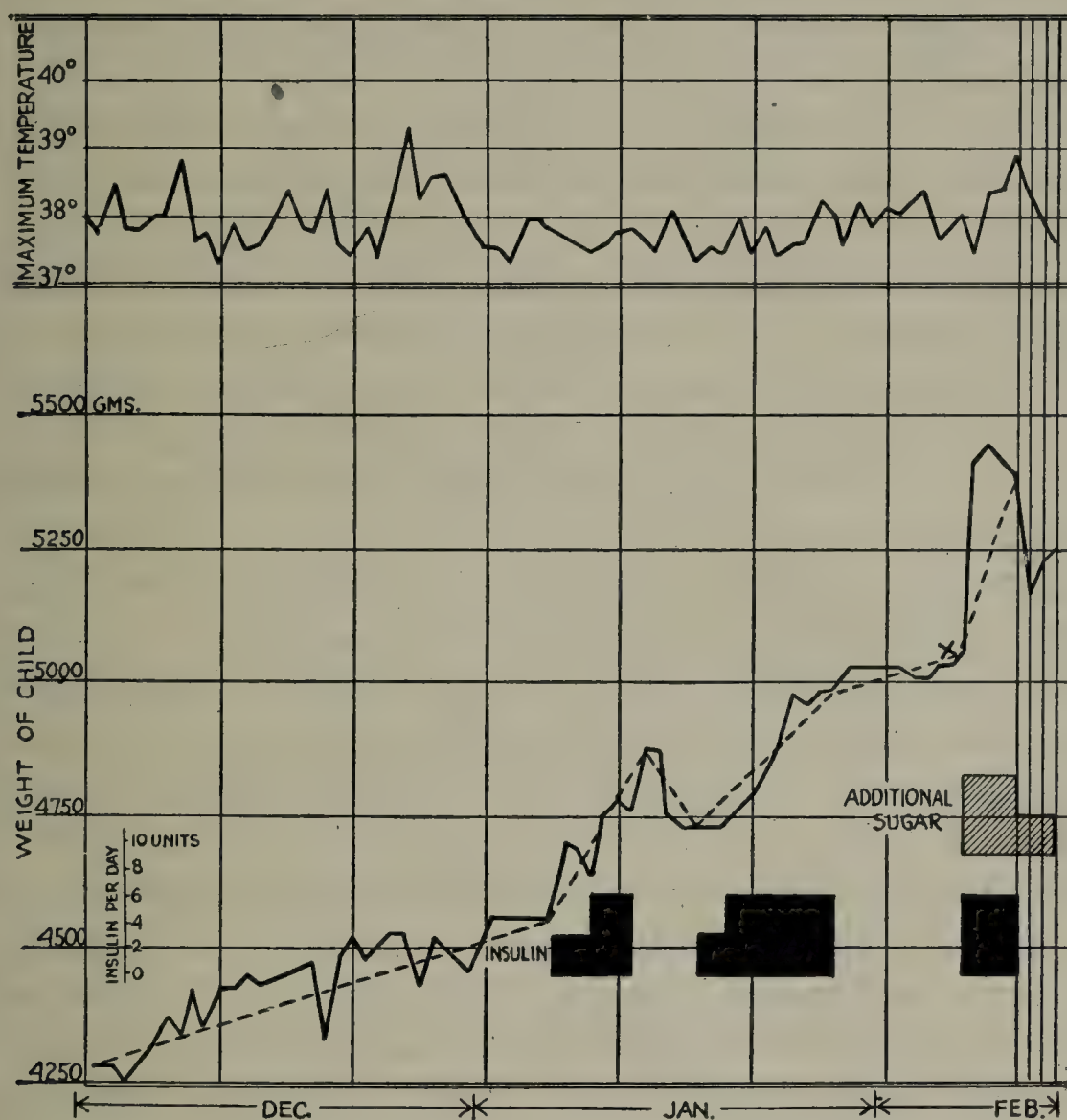


FIG. 23.—INFLUENCE OF INSULIN IN MALNUTRITION.

for infections. The longer the condition has persisted and the younger the child, the worse the prognosis. Some of these infants, if tided along for several months, seem to outgrow their difficulties. In hospital experience it is not uncommon to see a difficult nutritional problem solved simply by sending the child to a home environment—an indication that infants may become “hospitalized.” It is rather surprising that when recovery from marasmus does occur it is usually complete; the child at two or three years may be as large and vigorous as any child of his age.

## MALNUTRITION IN OLDER CHILDREN

Children above the age of two years who are much below normal weight and who fail to make, year by year, the usual gain in weight are the cause of much solicitude on the part of parents, and the care of such cases occupies a large part of the attention of one engaged in pediatric practice. The term malnutrition probably characterizes them better than any other. Although not actually ill, they are by no means well. There is constant fear lest they may develop some serious condition, especially tuberculosis.

As there is no absolute standard of health, so there is no absolute standard as



to what shall be classed as malnutrition. A convenient and much used one considers every child who is 10 per cent or more below normal or standard weight for height and age, as undernourished; also there should be placed in the same group those who regularly fail to make the normal gain in weight. The 10 per cent applies fairly well with children up to eleven or twelve years. Above this age a somewhat wider departure than 10 per cent from the average may be considered within normal limits.

**Etiology.**—So far as causes are concerned, the cases fall naturally into two groups: in one the condition is constitutional, being due to inherited or congenital causes; in the other it is acquired, largely as a consequence of the way in which a child has been reared. Certain children are delicate from birth, possessing only feeble vitality, though without demonstrating evidence of any actual disease. They are often the offspring of parents of delicate constitution and poor physical development. Others inherit a highly developed nervous organization and live under a tension which interferes with somatic growth. Still others are children who were premature or very small at birth.

The second group, in which malnutrition is an acquired condition, is much the larger one. The principal causes are ignorance or neglect of the common rules of hygiene, the observance of which is essential to normal healthy growth. First in importance are bad feeding and bad food habits. Insufficient food or an unbalanced diet may result from economic factors; they may result from bad training. The diet is usually composed very largely of carbohydrate, with comparatively little protein food; at other times the error may consist in giving indigestible food or stimulants. Bad eating habits include irregular hours for meals, eating between meals—especially of candy and sweets—coaxing and forcing of food, excitement of one kind or another at or just before meals. Too often these children are fed when they are not hungry or under conditions of emotional stress, when the motor and secretory functions of digestion are likely to be impaired. In a misguided attempt to put on weight they are frequently fed at short intervals, with the result that the stomach is not allowed to empty itself. They do not know what appetite is; their tastes become capricious, and because it is thought that any food they will take will do them good, they are allowed to continue on a very one-sided diet.

Next in importance to food is a proper adjustment of rest and exercise. Late hours, insufficient rest and sleep are important factors. Too much hard play may be just as bad in its effect as too little food. This is particularly the case with energetic, ambitious children. Bad housing, overcrowding, lack of fresh air in sleeping rooms, and in fact at all times, are also important.

Malnutrition may be the consequence of some previous acute illness, especially one affecting the digestive tract, or of some defect which interferes with growth. Of the latter, carious teeth, enlarged or diseased tonsils or adenoids are the most frequent. Malnutrition may be the earliest and for a long time the only evidence of some serious disease, such as tuberculosis.

**Symptoms.**—The symptoms of malnutrition are so familiar as to need but little description. The child is below weight for his height and age and often much below height for his age as well. Occasionally, however, one is too tall for age and weight, and the condition is ascribed to too rapid growth. The general physical



development is much below the normal. The younger children walk so late and often so clumsily that partial paralysis may be suspected. The muscles are flabby and soft and the ligaments often weak and relaxed. Endurance is feeble; they tire readily. In many children there is a moderate degree of secondary anemia with pallor of the lips and skin, poor circulation and frequently cold hands and feet. In some the skin is unnaturally dry, while others show a tendency to excessive perspiration. Moderate enlargement of the superficial lymph nodes is frequently seen. Nervous symptoms are present in most of the cases. As a rule, these children sleep badly, often suffer from night terrors, and develop a great variety of nervous habits, such as bed-wetting, nail-biting, or tics; they are fretful and irritable and usually somewhat difficult to manage. Their school work is generally poor; they are inattentive and find it hard to concentrate. Many show a strong desire for constant activity; they cannot sit still; they must be doing something every minute. Not a few are mentally very bright, even precocious, and are overambitious to stand at the head of the class. Others show the same ambition in sports.

Digestive disturbances are common in these children and are easily provoked. The tolerance for fats is likely to be low, and overindulgence is likely to produce vomiting. The tongue is often coated. Usually such children are constipated, but attacks of diarrhea, often with much mucus in the stools, are easily engendered.

One of the most striking things about children suffering from severe grades of malnutrition is their vulnerability. Catarrhal processes in the nose, pharynx and bronchi are readily excited, and, once begun, tend to run a protracted course. There is but little resistance to any acute infectious disease which the child may contract. Often one illness quickly follows another, so that these children are not infrequently sick for almost an entire season.

**Diagnosis.**—As has already been suggested, malnutrition at any age must be looked upon as a symptom which calls for a careful search for organic disease. Beside focal infections, one should consider especially tuberculosis, syphilis, diseases of the blood, intestinal parasites, and organic diseases of the digestive organs, heart, nervous system, lungs and kidneys. Malignant disease, though rare, should not be overlooked. It often requires repeated physical examinations, laboratory tests and close observation extending over some weeks before a positive diagnosis can be reached.

After excluding constitutional and local diseases, the whole life of the child must be investigated to discover to which one of the many possible causes the malnutrition is due. It is often difficult, and sometimes impossible, to get at the primary factor, for in cases of long standing there may be symptoms connected with almost every function of the body.

**Prognosis.**—The outlook will naturally depend upon whether definite causes can be discovered and whether these are capable of being removed. It is much better when the condition is acquired than when it is due to inherited or constitutional causes. But in the latter group, provided the children can be protected against common infections and acute digestive disorders, it is usual to find conditions improving year by year.

**Prophylaxis.**—In all cases very much depends upon the kind of coöperation that can be secured, not only from parents and nurses but from the child himself.



The education of children as early as seven or eight years in regard to the value of health, how it is to be gained and how it may be squandered, is no unimportant matter and well worth the thoughtful attention of the physician.

Preventive measures naturally can be applied only when malnutrition is due to conditions which are acquired. Since the largest causative factor in these cases is faulty hygiene, it follows that its correction is of the first importance. Continuous observations of the weight have been the most potent influence in arousing and maintaining interest. This may be done in the home, in the office of the family physician, in the clinic, or best of all probably in the school. The weight should be taken monthly or bimonthly. It should be appreciated by all who have the care of children that no child can be well who does not grow properly, who does not make approximately the annual gain in weight. Those who fail to do this should be regarded as needing the observation and direction of a physician, whose duty will be to search out the cause and apply the remedy. Other important preventive measures are the education and training of children from infancy in proper health habits.

**Treatment.**—The management of malnutrition, when it is an acquired condition, follows from what has already been said regarding causes. First, the removal of enlarged or diseased tonsils and adenoids, the removal or filling of carious teeth and the correction of bad posture or any other physical defects which may be discovered. The next thing is to substitute for the insufficient or improper diet one suited to the child's needs for normal growth.

Most of these children do better when a simple and fairly uniform diet is prescribed. Especially should candy, sweets, pastry, cakes, highly seasoned food of every description, and tea and coffee be avoided. Usually better results are obtained with three regular meals than with more frequent feeding, though with some, particularly those with good appetite but excessive expenditure of physical energy, smaller meals and something in the mid-morning or mid-afternoon will succeed better. Many of these patients get too much milk; it is never wise to give more than a pint and a half a day, and often less is better. Rich cream should be prohibited. Indigestible articles of food should not be given to tempt the appetite, and under no circumstances should children be continually coaxed or hired to eat; much less should they be forced to do so.

Next in importance to feeding in the management of these children comes rest. They have but little endurance and their strength must be carefully husbanded at every point. They must go to bed earlier than other children; hours of play must be reduced and a rest period of one or two hours made a part of the daily routine; some benefit also from being kept in bed until after they have had their breakfast. Not only physical but mental rest is necessary. Excitement and activity are what they crave and what must be studiously avoided. Some of them are essentially examples of neurasthenia. A complete change of environment often has a miraculous effect, particularly where the patient is an only child, the focal point of misguided family solicitude; he should be moved to a home where he will have the benefit of association with other children and where he ceases to be the center of attraction. What is needed in nearly all cases is usually quite obvious from an examination of the child and a history of his life; the difficulty lies in having the



needed reforms carried out. Removal from school is too often prescribed. It is more important to adjust hours of study, rest and play in school, and to regulate the home life of the child. Drugs have no place in the treatment.

The management of malnutrition when no obvious cause can be found—those cases in which congenital or inherited constitutional factors appear to be responsible—is not usually such a simple matter. Unremitting care and constant watchfulness are sometimes required to keep them up to even a moderate standard of health. There has been a tendency in recent years to attribute many of the symptoms above described to endocrine disorders and to employ endocrine therapy. There is no satisfactory evidence that such an etiology is correct or such treatment beneficial.

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Also see general references on nutrition given above.



## CHAPTER XIX

### CONSTIPATION

Constipation may be said to exist whenever the stools are firmer or less frequent than normal. The breast-fed infant usually passes two or three soft stools a day. The stools of the artificially fed infant are somewhat firmer and less frequent; they may be passed only once a day and at times a day may be missed. Such a condition is not to be regarded as constipation; it should occasion no concern, nor does it require treatment.

**Etiology.**—Constipation may be due to the food or to anatomical or functional abnormalities of the intestine. A diet relatively high in protein and relatively low in sugar is likely to be constipating; this is attributed to the fact that putrefactive bacteria overrun the fermentative organisms; the products of fermentation—the volatile fatty acids—are regarded as being laxative. Milk feedings to which curd (largely calcium caseinate) has been added, such as protein milk, are particularly likely to be constipating; this is due to the formation of insoluble calcium soaps which add bulk to the stool and do not appear to stimulate peristalsis readily. For some infants, boiled milk appears to be constipating. A diet which lacks residue is a common cause of constipation in older infants and children. The difficulty may lie in the continued use of strained vegetables or the administration of much carbohydrate in the form of starch rather than the whole-grain cereals.

Functional disturbances in the bowel are far more common than organic causes. The most common cause of muscular atony is habit. If the inclination to have a stool is regularly disregarded, it soon ceases to be felt; the ordinary fecal masses produce no response whatever. The longer such a condition persists the more obstinate does it become. This is an important factor in all cases. Rickets or any condition of chronic malnutrition may aggravate or predispose to constipation. Want of sufficient exercise is a frequent cause. There are many children who rarely suffer from constipation in the summer when they have plenty of outdoor exercise, who very often do so in the winter when such exercise is wanting. A loss of muscular tone is not an infrequent result of the prolonged and indiscriminate use of purgative drugs or enemata. Constipation is almost invariably present in cretinism. Certain cases of constipation can be attributed to autonomic imbalance. The striking results that have been obtained in certain cases of Hirschsprung's syndrome by blocking sympathetic impulses indicate this to be the case. Spasm of the colon as a cause of constipation is discussed elsewhere (see page 297). Weakness or paralysis of the abdominal musculature from any cause usually leads to constipation.

Anatomical anomalies may be responsible. An unusually long mesentery causing kinking of the bowel is usually mentioned as a cause. Anal fissures may cause the individual to resist defecation. In our experience these fissures are more often the result than the cause of the difficulty. Anal stenosis is, however, a very real, if



infrequent cause of constipation. The orifice may be so small that the little finger is passed in with great difficulty.

**Symptoms.**—In most children no symptoms are present except the local ones. The expulsion of a constipated stool may be accompanied by local pain; not infrequently the surface of the fecal mass is streaked with blood from a scratch or pressure of the anus. There may be a mild mucous colitis from the irritation of the hardened fecal masses. The constant straining may, rarely, lead to hemorrhoids or to prolapse of the rectum. It is doubtful if hernia is thereby produced, but it is quite possible that the healing of umbilical hernias may be somewhat delayed. Symptoms which might be referred to absorption of toxic materials are singularly infrequent; far too much attention is paid to this rather remote possibility. One need only recall the experiments of Alvarez on adults, in whom the sensations usually ascribed to toxic absorption were duplicated by the insertion of an inert foreign body (cotton) in the rectum. Moreover, patients with Hirschsprung's disease who may be constipated for weeks at a time experience no such symptoms.

When constipation is due to the food or to muscular atony, the stools are usually hard. When the difficulty is due to a partial obstruction of the anus the stools are soft and often ribbon-like. Dilatation of the anal orifice with the finger is likely to relieve the constipation at once.

**Treatment.**—Constipation should be combated by training, exercise and diet; laxatives should be employed only as temporary expedients. Successful treatment demands a careful regulation of the child's routine, which must be continued for a long period of time.

With young children, more depends upon *training* than upon anything else; this should be begun in early infancy. Even in young infants regular habits are formed without difficulty if the child is put upon the chamber or chair at the same hour each day. When a local stimulus is required in addition, an oiled glass rod or a gluten suppository may for a time be inserted. The cone of oiled paper has a great reputation in domestic practice and is not objectionable. It may be of assistance in establishing a proper habit. An older child must be taught to heed the first impulse to evacuate the bowel. Regular habits can hardly be formed unless the same time each day is chosen for the movement.

**Exercise.**—When properly employed, massage is useful in conjunction with other measures; it rarely succeeds alone. It should be given for five or ten minutes after retiring and just before rising. A proper amount of general muscular exercise is necessary and should be made part of the treatment of every case. Special exercises for the development of the abdominal muscles, when faithfully carried out, may be of benefit.

**Diet.**—Constipation is uncommon in nursing infants; if necessary, they may be given additional orange juice or prune juice from a bottle. With artificially fed infants, constipation is frequent. It may be combated by the use of more sugar in the diet, particularly the liquid preparations of malt. Fruits—orange juice, prune juice, apple sauce and other strained cooked fruits—may be used. After five or six months of age, one may give diets containing more residue—unrefined cereals and green vegetables; sometimes the replacement of part of the milk with solid food has the desired effect.



During the second year the amount of milk may be reduced for this purpose to as little as a pint a day. Unstrained fruits may be given and a greater amount of roughage allowed. Whole-grain cereals and breadstuffs should be substituted for flour and refined cereals as far as possible. Meats and vegetables may be given finely chopped instead of strained. Bran may be added to the diet. For older children the same principles apply; with increasing age, a larger amount of fruit and roughage is permissible. Fermented milk may be of some benefit. The laxative effect of sugars may be utilized with older children. Two or three teaspoonfuls of honey may be given with the breakfast or supper. Molasses may be given upon the bread or may be added to cooked foods. Water should of course be given in sufficient quantity; it is, however, in no sense a laxative.

*Suppositories.*—Suppositories of gluten or cocoa butter may be used in training young infants; they produce little irritation and can consequently be used repeatedly. They may, however, require several hours to act. Soap suppositories and, more particularly, glycerin suppositories are more irritating and should be used only occasionally; their action is prompt.

*Enemata.*—These (see also page 66) have no place in the treatment of chronic constipation; for immediate relief they are sometimes necessary. Cases of fecal impaction are rare in children. They are to be managed as in adults by repeated injections of soap and warm water, and sometimes by mechanical removal. The injection of olive oil or mineral oil may be of value in softening the masses.

*Medicinal Treatment.*—Medicinal treatment is the least important part of the management of chronic constipation. One's aim should be to dispense with it entirely, and to control the condition by training and diet alone. If this proves impossible, recourse may be had to preparations which are not irritating or habit forming. Mineral oil is probably the best of these; it acts solely as a lubricant. One teaspoonful a day may be given to infants and two teaspoonfuls to older children as a starting dose, the quantity being increased until satisfactory results are obtained. It is best given apart from the meals; given with them it may provoke regurgitation. Agar is an equally bland and almost equally useful cathartic; a teaspoonful of the powder may be sprinkled on the food once or twice a day. Combinations of mineral oil and agar are available. Milk of magnesia is a sufficiently mild laxative for continued use. Other cathartics, such as castor oil, phenolphthalein, cascara, rhubarb, senna, aloin, saline cathartics, etc., should only be used when acute purgation is desired. The official A. S. and B. pill should, in particular, be avoided with infants; many fatalities from strychnine poisoning have been reported from its use.

If a lubricant or laxative is necessary for the control of chronic constipation, one should employ only the minimum dose necessary to supplement what can be accomplished by training and diet. When proper habits are well established one can diminish the dose gradually over a period of weeks until medication is no longer needed. It is a popular misconception that a child's bowels should move at least once a day—a notion which has led to the indiscriminate use of enemata and laxatives and which too often delays the successful treatment of constipation.

It is not possible to lay down a regimen applicable to all cases. The cause of the difficulty must of course be taken into consideration. If it is due to anal stenosis



is obviously absurd to concentrate on the diet. It is a wise policy to make a digital examination of the anus in all cases of chronic constipation in infants. If the orifice is unduly small it should be dilated daily with the finger.

Although it is generally preferable to control constipation by the diet rather than by medication, there are exceptions to this. The amount of roughage which young infants will tolerate is limited. Whenever there is evidence of irritation of the intestinal mucosa with mucus in the stools, roughage is to be avoided; it is far better to use lubricants. The same may be said of celiac disease (chronic intestinal indigestion) and spastic colitis; with such, roughage is undesirable.

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## CHAPTER XX

### COLIC AND FLATULENCE

**Colic.**—The term “colic” describes a symptom: paroxysmal abdominal pain. It is due to exaggerated peristalsis in the face of an obstruction which may be organic or may result from spasm. In infancy and childhood it is most commonly seen in acute indigestion with flatulence, but it is also present in intussusception, appendicitis, and most acute inflammations of the intestine. It often follows the use of cathartics. Foreign bodies in the digestive tract occasionally become obstructed and cause colic—something that has been swallowed or, rarely, a mass of round worms. It may accompany constipation. In infancy it may be precipitated by exposure to cold or the ingestion of cold food. Colic is sometimes seen after ingestion of a food to which the patient is sensitive. Lead colic is very rare in children.

Some writers, particularly in Germany, believe that “colicky” infants form a definite constitutional group, characterized by hypertonicity of the voluntary muscles, exaggerated reflexes, and a neurotic background.

In infants the paroxysms of intestinal colic are manifested by severe crying, during which the features are pinched, the legs are drawn up, and in males the cremaster muscle contracts. These symptoms may subside for a few moments, to recur later with renewed intensity. The abdomen is usually distended. Sometimes the attack is relieved suddenly with the explosive passage of gas by rectum. In older children there is periodic exacerbation of abdominal pain, localized at the umbilicus and coming in cramp-like waves but not entirely subsiding between attacks. In severe cases there may be considerable prostration, with perspiration and cold extremities, and in some of these it is possible that there is a transient intussusception.

Colic is easily mistaken for hunger; infants suffering from colic may take food eagerly and be relieved temporarily; the pain soon returns, however, and it is often more severe than before. The cry of colic is more likely to be paroxysmal, while that of hunger is apt to be prolonged and continuous. The cry of a spoiled child may be mistaken for that of colic. A helpful point in eliminating hunger and spoiling is the sudden appearance of symptoms in an infant previously well behaved.

Symptomatic treatment is urgently indicated in colic. An enema and the application of heat to the abdomen are harmless measures and may give prompt, even if only momentary, relief. One must not lose sight, however, of the possible organic causes of abdominal pain. The unwise administration of cathartics to patients with appendicitis or intussusception, for the relief of pain in supposedly functional disturbances of digestion, has been responsible for many unnecessary deaths. If an organic cause can be ruled out, one may obtain further relief by the administration of carminatives (such as a soda-mint tablet), by atropine, or by gentle abdominal massage.



Without doubt older children will continue to eat green apples and to have colic. There can be little doubt, however, that colic among infants is on the wane. The older clinical treatises bear witness to the former frequency of this symptom; at the present time colic is rarely seen in infant's hospitals, although somewhat more common in private practice. The disappearance of colic may be attributed to two factors: better infant feeding and better diagnosis. Many supposed instances of colic were examples of hunger or of a spoiled child crying to be taken up. Adequate feeding and the use of boiled milk rather than raw milk have doubtless reduced the incidence of this condition.

**Flatulence.**—Flatulence may be the result of abnormally active bacterial fermentation, or of air-swallowing with failure to expel the air from the stomach by belching. This alone does not give rise to colic, for the latter is absent from most cases of distention associated with rickets and even from severe examples of air-swallowing. When there is colic from acute indigestion, however, it is almost invariably accompanied by flatulence; both symptoms are successfully treated by the measures mentioned above. A young patient suffering from abdominal distention and too ill to move about in bed, as is sometimes the case in pneumonia and typhoid fever, may obtain relief by having his position changed from time to time; infants especially are helped by being placed in the prone position. A rectal tube may be of assistance.



## CHAPTER XXI

### CELIAC DISEASE

Celiac disease (chronic intestinal indigestion, intestinal infantilism) is a chronic disturbance of nutrition characterized by arrest of growth, a distended abdomen and attacks of diarrhea with large, pale, foul-smelling stools. It was first described by Gee in 1888. It is not a very common condition. In the Harriet Lane Home in Baltimore it occurred about once in every fifteen hundred admissions; in the British Isles it appears to be more frequent. It occurs in all grades of society, but particularly among the well-to-do. It is probable that among the poor these patients die early for want of careful supervision. Fanconi has pointed out that the disease is more frequent in communities where the infant mortality rate is low.

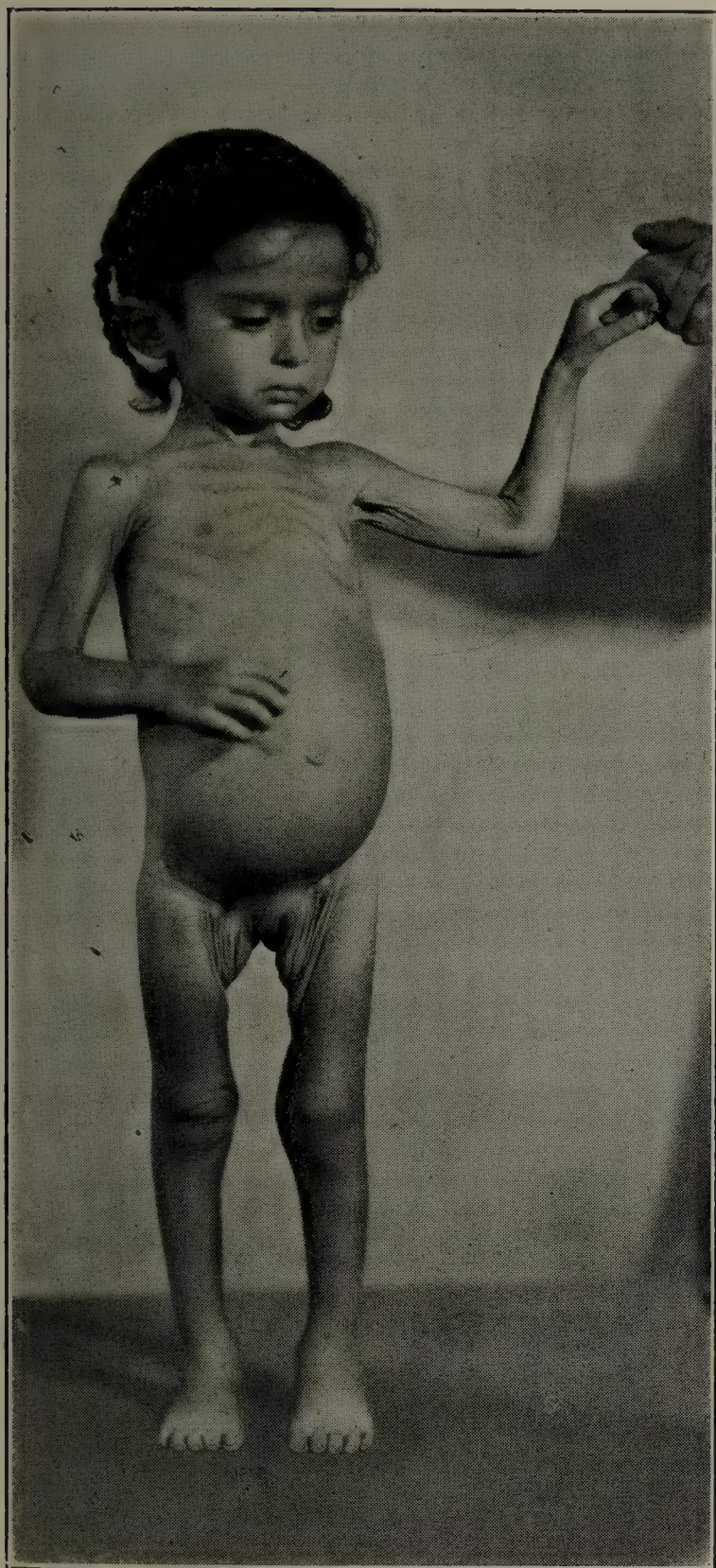
Among 54 cases in children analyzed by Fanconi, the age of onset varied between four months and sixteen years; the majority, however, began between the first and third birthdays. The typical picture of the disease is rarely attained before the end of the first year, although symptoms may have been present for some months. Celiac disease appears to differ in no essential way from the cases of nontropical sprue sometimes seen in adults.

**Symptoms.**—The disease may follow an attack of indigestion from which complete recovery does not take place. In other instances the onset is insidious. The first symptoms are found in the digestive tract. The stools are numerous and bulky, containing an excess of fat. Sooner or later the general nutrition suffers; the patient fails to gain weight and loses his appetite. In an effort to overcome these difficulties the feeding is often changed frequently, which may make matters worse and too often precipitates an attack of diarrhea. As the nutritional disturbance continues and more weight is lost, the child becomes less active. The abdomen becomes more prominent and nervous symptoms are likely to develop.

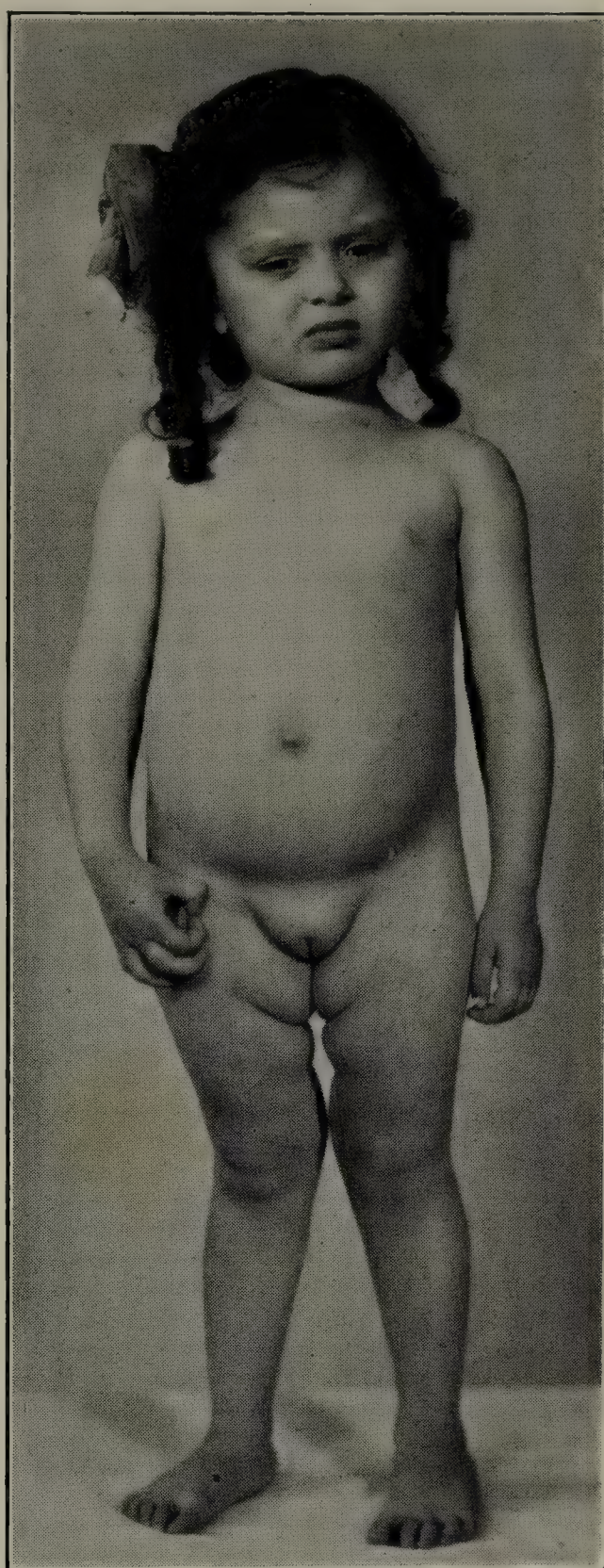
A well-marked case presents a characteristic picture. The patient is usually very thin, with wasted extremities and a small amount of subcutaneous fat. There is marked pallor and a sallow, haggard appearance with dark rings under the eyes. Perhaps the most striking feature of the condition is the large protruding abdomen. This is due partly to excessive intestinal fermentation and partly to atony of the abdominal musculature. The abdominal wall is often so thin that intestinal patterns are readily seen. The distention involves the large and the small intestine equally, a point which is of some assistance in diagnosis. Tympanites is constantly present, especially during the daytime, when large quantities of gas may be passed. In order to balance his distended abdomen, the patient stands with his head and shoulders tilted backward to some extent.

The bowels are usually constipated, the stools being bulky, light gray in color





A



B

FIG. 24.—CELIAC DISEASE.

Ida B., first seen at two years of age. (A) Breast fed for eight months; had had occasional attacks of diarrhea from the age of thirteen months on, with progressive loss of weight and almost continuous diarrhea for six months. She weighed 9350 grams (20 pounds, 10 ounces) and measured 84 centimeters (33 inches) in length. Severe malnutrition, with irritable disposition but no other objective findings of note. There was marked secondary anemia, hemoglobin 56 per cent, red blood count 5,000,000. Blood sugar curve with ingestion of 1.75 grams glucose per kilogram of body weight; control, 114; 1 hour, 120; 2 hours, 128 milligrams per 100 c.c. On a diet consisting at first of protein milk and banana, the weight remained approximately stationary for four weeks, then rose at the rate of about 350 grams a week, additions to the diet being made progressively. On discharge she took a diet essentially normal for a child of her age except that only skimmed milk was allowed.

At three years, two months of age (photograph B) she weighed 15,750 grams (34 pounds, 10 ounces) and measured 95 centimeters ( $37\frac{1}{4}$  inches) in height.



and often very foul. The pale color is not due to deficiency of bile pigment, for the color darkens on standing. It is characteristic of the disease that attacks of diarrhea are likely to supervene, often without apparent cause. The diarrhea is not usually extreme, seldom more than 5 or 6 stools a day being passed; they are of variable color, acid in reaction, often frothy and offensive; they always contain undigested food. From time to time, in many patients, much mucus may be passed; this may become a constant feature of the disease. A striking feature is the large size of the stools; on a milk diet the chief constituent of the stools seems to be fat, which may form as much as 60 to 70 per cent of the solid matter of the stool, the normal proportion seldom exceeding 30 to 40 per cent.

Children with celiac disease often show marked nervous symptoms. They are irritable, emotional, and exceedingly difficult to manage; they are easily fatigued. The appetite is usually poor and often capricious, a factor which adds to the difficulty of treatment. Sleep is usually disturbed; they wake frequently, crying out and often grinding the teeth. During the day their activity is on the whole below that of a normal child; it is not uncommon, however, to see such a child tossing from side to side in his crib for hours at a time. Vasomotor disturbances are common. These children perspire easily; they usually suffer from cold extremities. Very young children when affected by the disease are usually late in walking and talking, and are hence often regarded as being mentally below par. With convalescence, however, it is apparent that they are mentally normal. Older children, even though very backward in their physical development, are often quite precocious mentally, a fact which may be attributed to their constant association with adults.

When celiac disease has lasted for any length of time, growth is always retarded, both in height and weight. One of our patients at three years weighed 12½ pounds and was 29 inches tall; another at five years weighed 22 pounds and was 33 inches tall. The epiphyseal centers of ossification are often much delayed in their appearance. Parsons has pointed out that many of these children suffer from true rickets; tetany is by no means a rare complication. Roentgenograms of the long bones may show typical changes at the epiphyseal line; more often there is only a very pronounced osteoporosis; there may be seen transverse lines of calcification near the epiphyseal end of the diaphysis, corresponding to exacerbations of the disease with arrest of bone growth.

Fever is usually absent in celiac disease, but in some cases a temperature varying between 99° and 101° F. may continue for weeks at a time. Higher temperatures may occur with acute exacerbations. One of the characteristic features of the disease is the hydrolability, or quantitative variability of tissue fluids; losses or gains of 10 per cent of the body weight may occur in twenty-four hours. Edema is not uncommon, and most patients can be made to develop it by suddenly increasing the intake of sodium chloride. Among the rarer complications may be mentioned cachectic purpura, pigmentation of the skin, and scurvy.

**Etiology.**—In spite of numerous studies that have been made, the etiology of celiac disease is still obscure. Some cases, though by no means all, have shown fibrosis and cystic changes in the pancreas. The histology of the intestines is quite



normal. Atrophy of the lymphoid tissue, disappearance of subcutaneous fat and disappearance of glycogen from the liver are the result of the chronic disturbance of nutrition. The extensive studies made by Herter on the bacterial flora of the intestinal tract failed to reveal any bacterial cause for the disease. Most of our information in regard to its nature has come from chemical studies. The digestive secretions are usually normal. Although gastric achylia has been observed, this is the exception rather than the rule. Studies of the gastric and duodenal enzymes have shown that these are present in sufficient quantity; fats, carbohydrates and proteins are well split; the difficulty appears to lie in the absorption and utilization of the fats and carbohydrates in particular, and, secondarily, in the mineral metabolism.

It has already been mentioned that the stools contain an excess of fat. Except in periods of diarrhea, this fat is well split. The excess fat of the stools represents chiefly failure of the intestine to absorb the normal proportion of fat. This finding is confirmed by the recent observation of Parsons on the blood fat. The fasting blood fat is low in celiac disease; after a fat meal it fails to rise to the extent occurring in the normal individual—a flat lipemic curve is obtained. Further evidence in support of a failure of proper fat absorption, rather than excessive excretion of fat into the intestine, as proposed by Bauer, was obtained by Parsons, who studied the iodine number of the lipoids of the diet and of the stools in his patients and found a marked parallelism between them.

Quite similar to the alimentary lipemic curve is the blood sugar curve obtained after the administration of glucose—a flat blood sugar curve is obtained (see page 122). The fasting blood sugar may be subnormal. The explanation of the flat sugar tolerance curve is still in doubt. It may be due to defective absorption from the intestine or to abnormally rapid utilization by the tissues. In favor of the latter view are a few observations of MacLean and Sullivan that glucose given intravenously disappears from the circulation with unusual rapidity. More observations will be required to settle this point. Determinations of the respiratory quotient and the basal metabolic rate in celiac disease have in some instances indicated an increased combustion of carbohydrate, but here again the observations are too few to be convincing.

Proteins are usually well digested and absorbed by celiac patients. In a certain number of cases, however, there is evidence of hypersensitiveness to food proteins, particularly those of milk, which may be due to increased permeability of the intestine to unsplit protein in some acute phase of the disease.

Disturbances in the mineral metabolism are usually found. Even in nondiarrheal periods, large amounts of sodium and chlorine may appear in the stools. Calcium and phosphorus are poorly absorbed with great regularity; the concentrations of both of these elements in the blood serum are likely to be below normal. There is every reason to believe that this metabolic defect is identical with that occurring in rickets in small infants. Fanconi has pointed out that in celiac disease a lability of the calcium and phosphorus levels of the blood exists, similar to that which occurs in ordinary rickets. It seems likely that with the disturbance in fat absorption, the celiac patient absorbs an inadequate amount of vitamin D, and that the occurrence of rickets and tetany can be directly attributed to this.



TABLE XXIX  
METABOLISM IN CELIAC DISEASE \*

	Percentage of Intake Retained							
	Fat	Nitro- gen	Na	K	Ca	Mg	Cl	P
Average of 8 active cases.	75.3	12.5	—10.6	11.8	3.3	—1.1	—2.7	2.7
Average of 9 observations on 5 convalescent patients	82.4	31.3	25.8	21.2	31.6	27.0	25.1	27.7

\* These figures are taken from observations of Holt, Courtney, and Fales, previously unpublished except for one case (*Am. J. Dis. Child.*, 1917, 14: 222).

Curiously enough, vitamin A deficiency is rarely seen in celiac disease. It is claimed that the poor appetite often seen is due to inadequate vitamin B, a point which, however, is not yet clearly established.

Although much of the chemical pathology can be attributed to alterations in intestinal absorption, the cause for these remains unknown. The older views that the condition is the result of too high a fat intake or of the use of solid food at too early an age are no longer held. Only a small percentage of the cases can be attributed to allergy. It is possible that some unrecognized infection is at the root of the difficulty. The endocrine glands have been blamed, as for most obscure disorders, but the only direct evidence bearing on this view is the observation of Parsons, who has noted that certain children when they recover from celiac disease lay down fat in the typical Fröhlich distribution.

**Diagnosis.**—There are comparatively few conditions with which celiac disease may be confounded. Because of the distended abdomen it is sometimes mistaken for Hirschsprung’s disease or tuberculous peritonitis. In *Hirschsprung’s disease* the symptoms are noted soon after birth; the distention is confined chiefly to the large intestine, and constipation is more obstinate. The distention is due to fecal masses rather than flatulence. The stools do not resemble those of celiac disease, nor are nervous symptoms or disturbances of growth prominent.

In *tuberculous peritonitis* it is usually possible to demonstrate fluid or masses in the abdomen. Shifting of the intestinal contents in celiac disease may simulate a small amount of fluid, but this should not deceive an experienced observer. The tuberculin reaction and clinical and roentgenological evidence of tuberculosis elsewhere give valuable information. In neither abdominal tuberculosis nor Hirschsprung’s disease are evidences of perverted carbohydrate, fat or mineral metabolism found.

Following dysentery there may persist a state in which the intestine remains highly irritable, and attacks of diarrhea with mucus are easily provoked. Fruits in particular are poorly tolerated; fats and carbohydrates are, however, well digested. There is little tendency to flatulence and abdominal distention. The metabolic changes observed in celiac disease are not found.

An unusual condition easily confused with celiac disease is *chronic pancreatic insufficiency* due to atrophy or rudimentary development of the pancreas. The most extreme steatorrhea occurs in this condition; owing to the absence of lipase very



little fat-splitting occurs—in contrast to celiac disease. Growth may be seriously interfered with, giving rise eventually to “pancreatic infantilism.”

**Treatment.**—The treatment of celiac disease is a question of diet and management. Recovery is at best a slow process and the relapses which must be expected are most trying to anxious parents. It is of the foremost importance that the treatment be carried out rigidly for a long period, which may be months or several years. If the parents are inclined to be lax in discipline and unable to control the child, an efficient nurse should be secured.

The diet used is based upon the view that celiac disease is primarily a condition of intolerance to certain foodstuffs. Fats are avoided, since they are poorly absorbed. Glucose or invert sugar (glucose and levulose) appears to be better tolerated than polysaccharides. Protein is usually well digested and the bulk of the diet is therefore composed of protein and monosaccharide. It has been almost the universal experience that sweet milk is badly tolerated by these infants. Many of them do well when sour milk preparations are used or when casein is given in the form of curd. Others do better when milk proteins are omitted altogether. Protein may then be supplied in the form of scraped beef or eggs. Ripe bananas supply invert sugar in a convenient form, and are very useful in the treatment of the disease.

In most cases it is possible to begin with a diet of meat, egg, curds, buttermilk, banana and glucose. One should not attempt in the beginning to cover the caloric requirements. Neither these nor the child's appetite should determine the amount of food, but what he is able to digest. To go beyond this is simply to increase the bulk of the stools. Care must always be taken to give an adequate amount of water. The bowels should be kept open by the use of lubricants. Roughage should be avoided, since it only serves to irritate the intestine and may precipitate an attack of diarrhea. Some form of vitamin D should be given from the start, viosterol often being better borne than cod liver oil. Orange juice in sufficient quantity to prevent scurvy ( $\frac{1}{2}$  to 1 ounce a day) does not disturb digestion.

When there is evidence of improvement in the character of the stools, one may increase the quantity of food and return gradually to a normal diet. Opinion differs as to whether this should be done by first introducing a greater variety of carbohydrate foods, or whether the next step should be the introduction of more liberal quantities of fat. In our experience, no rule can be laid down. The degree of intolerance for carbohydrate or fat varies in individual cases, and one must proceed empirically, introducing one new food at a time and waiting several days to ascertain its effect. One should not lose sight of the fact that in these patients all symptoms are greatly influenced by the emotional state. Satisfactory improvement may depend on a proper adjustment of the emotional environment.

**Prognosis.**—The course and duration of the disease are indefinite. With proper treatment milder cases often recover in a few months, though careful feeding must be continued for years to prevent relapses. The more severe cases may last several years, and not infrequently these patients fall victim to intercurrent infections. The natural course of the disease is characterized by ups and downs, which are reflected in the patient's disposition. Attacks of acute indigestion with diarrhea and sometimes vomiting are easily excited. Such relapses often occur



without demonstrable cause, the patient losing in a few days all the gain made in several weeks. With intelligent treatment recovery occurs eventually in the large majority of cases, although in the more severe ones some stunting of growth is likely to persist. Improvement is first noticeable in the digestive symptoms, then in the nervous manifestations and lastly in the weight curve.

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## SECTION IV

### DEFICIENCY DISEASES

Much of our knowledge of the deficiency diseases has been gained by animal experiments. The deficiency syndromes occurring in man, although similar to those of the experimental animal, present certain species differences. Moreover, in man it is unusual to encounter a defect of one accessory food factor only. Human diets, when defective at all, are likely to be lacking in several factors; the disease pictures are therefore more difficult to separate.

## CHAPTER XXII

### DEFICIENCY OF VITAMIN A

(XEROPHTHALMIA; KERATOMALACIA; NIGHT-BLINDNESS)

This is a comparatively infrequent condition in the United States, although in certain parts of Asia and in Labrador it is by no means rare. During the late war, deficiency of vitamin A became acute in many parts of Europe; in Denmark between 1914 and 1918 more than 700 cases of keratomalacia were observed in infants and young children. The disease is likely to develop on diets which are defective in butter and green vegetables; lard and vegetable oils are notoriously poor in the A factor. Although there was an abundance of butter in Denmark at the time mentioned, it was used for export, the children being fed on fat-free diets or receiving their food fat in the form of margarine or vegetable oils.

Vitamin A deficiency is found in two types of infants: (1) those who have suffered from chronic disturbances of nutrition, in which assimilation of fat (and presumably of vitamin A) is defective, and (2) those who have been given diets very poor in fat. In many instances the fat-poor diet has consisted of some proprietary food composed largely of carbohydrate; recently, however, a number of the manufacturers of such foods have added cod liver oil to their product, and this source of the disease is disappearing.

A diet poor in the fat-soluble A factor must be continued for weeks or months before symptoms develop. One of the earliest manifestations is night-blindness or inability to see in dim lights (*hemeralopia*). This is almost invariably the first complaint in subjects who are old enough to appreciate it. In infants, night-blindness, if it occurs, is not recognized; the disease does not attract attention until changes in the cornea and conjunctiva appear. Deficiency of the A factor produces hyperkeratinization of the epithelium of the conjunctiva, the cornea, the lacrimal glands, the salivary and pancreatic ducts and to some extent of the respiratory tract. The secretions of the gland are inhibited, and the early changes in the eye have been attributed to defective lacrimal secretion. The first alteration is seen in



the cornea, which exhibits a slight haziness, developing gradually into a bluish-gray opacity. The condition is usually diffuse rather than localized in patches; the conjunctiva becomes dry and rough (xerosis); there is loss of sensation and the lids tend to adhere to the eyeball. Photophobia is not striking. If the disease is allowed to progress further, destructive changes take place; the cornea ulcerates and may perforate. These destructive changes are apparently due to secondary bacterial invasion. The entire upper respiratory tract is said to be more susceptible to infections of all kinds.

The symptoms of vitamin A deficiency respond rapidly to treatment. Night-blindness clears up entirely. If treatment is commenced before the corneal changes are advanced, complete healing may take place, the cornea returning to normal. More often the process is not recognized until some necrosis of the cornea has occurred, and the ultimate result is a corneal opacity.

Cod liver oil is a highly potent source of vitamin A. It should be given promptly, as soon as symptoms of vitamin A deficiency are recognized. Oral administration is usually sufficient in quantities of one or two teaspoonfuls a day, but there have been instances recorded with impaired fat assimilation, which failed to respond to oral administration but improved quickly when a preparation containing vitamin A was given parenterally. Irradiation of foods or of the body is without influence upon the A factor.

Until recently little was known in regard to the chemical nature of the A vitamin, beyond the fact that it was found in the nonsaponifiable fraction of various lipoids. Recently, evidence has accumulated that it is formed from the lipochrome pigment *carotin*, a constituent of many animal fats and of many vegetables. It is of interest to note in this connection the observations of Clausen, who has found that a definite inverse relation exists between the carotin content of the blood and the presence of infections. The international standard unit of vitamin A has been adopted as 1  $\gamma$  (0.001 milligram) of carotin.

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## CHAPTER XXIII

### BERIBERI

Infantile beriberi is rarely seen in the United States; it is common in China, Japan, the East Indies and the Philippine Islands—in fact, wherever beriberi is found in adults. Nearly all of the cases occur in nursing infants whose mothers are suffering from the disease; in some instances the mother, although presenting no symptoms, has been taking a diet deficient in vitamin B. Andrews has shown that infantile beriberi can be attributed to deficiency of this vitamin in the mother's milk.

The clinical picture of the disease differs in some respects from that observed in adults; motor symptoms are less prominent. The disease usually manifests itself between one and three months of age; it may be ushered in with a gastric upset, but more often the onset is insidious. The infant is restless and fretful and sleeps poorly. His appetite fails and he tends to lose weight; a secondary anemia may develop. One of the most characteristic symptoms is an alteration in the quality of the voice, which often progresses to complete aphonia. There is general weakness and loss of muscular activity; there may be hyperesthesia, the infant crying when disturbed; tenderness of the calf muscles in particular is described. The knee jerks are lost. Attacks of colicky pain and meningeal symptoms may occur; the spinal fluid, however, is normal. Sooner or later evidences of cardiac failure appear. The pulse is rapid, there is cardiac enlargement, cyanosis and edema; the urine, although diminished in amount, is normal. Fever is not present. Death results usually from progressive heart failure, but may occur suddenly with convulsions. A fatal outcome may be averted by prompt treatment. The lesions found at autopsy resemble closely those of the adult disease. There is a definite peripheral neuritis; the right heart shows dilatation and hypertrophy; there is visceral congestion.

Following the observation of Macy and others that both human milk and cow's milk contained insufficient vitamin B for the proper growth of rats, Hoobler has recently made the suggestion that many of the symptoms associated with malnutrition in infancy are due to a partial deficiency of the antineuritic factor. The symptoms attributed to this defect are pallor, anorexia, failure to gain weight, fretfulness and restlessness with a tendency to spasticity of the neck and extremities. It is claimed that marked improvement follows the administration of vitamin B.

This view has led to the extensive use of preparations containing vitamin B—notably wheat germ and brewer's yeast—in every variety of nutritional disturbance in childhood. From the conflicting reports it is difficult to form an opinion as to the effectiveness of this treatment or the correctness of the view upon which it is based. One cannot assume that a milk which may be deficient for such a rapidly growing animal as the rat is necessarily deficient for man; the vitamin require-



ments of different animal species vary enormously; only human observations are of value in indicating a deficiency in man. The symptoms in question are by no means specific. If they were due to lack of vitamin B in the food, one would expect to find them more frequently in breast-fed infants, since it has been shown that this usually contains less vitamin B than cow's milk. However, the picture has not been reported in breast-fed infants. It is our experience and that of many competent observers that improvement in such symptoms following the administration of vitamin B is most unusual. We are therefore inclined to regard the syndrome of partial vitamin B deficiency as not yet established.

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## CHAPTER XXIV

### SCURVY

Scurvy (scorbutus) is a disease caused by the prolonged use of a diet deficient in vitamin C. It is characterized by changes in the growing parts of the bones and by a general hemorrhagic tendency. The most striking symptoms are due to epiphyseal separation and subperiosteal hemorrhage; these occur particularly in the long bones of the lower extremity, usually about the knee and ankle, causing hyperesthesia and pseudoparalysis of the legs. The hemorrhagic tendency is manifested by spongy, bleeding gums, hemorrhages in the skin and mucous membranes, and sometimes by bleeding into the urinary or the gastro-intestinal tract.

The disease was formerly common among sailors and on expeditions in which fresh fruit and vegetables were not available. In infants it was recognized as early as the seventeenth century, being mentioned in the writings of Glisson. For our earliest modern knowledge of the pathology of the disease we are indebted to the observations of Barlow and Cheadle. Möller in Germany described the clinical picture somewhat earlier but interpreted it as acute rickets. On the Continent, infantile scurvy is often spoken of as Möller-Barlow's disease. Its identity with adult scurvy was not appreciated at first, but is now generally conceded. An important landmark in the study of scurvy was its production in experimental animals by the Norwegian investigators Holst and Frölich in 1907. This made it possible to study the distribution of the vitamin in nature and the factors influencing its stability long before it was isolated in pure form.

**The Vitamin.**—The chemical properties of ascorbic (cevitamic) acid and its occurrence have been discussed on page 109. The juice of citrus fruits constitutes a reliable and exceptionally constant source, fresh orange juice containing approximately two-thirds of a milligram per c.c. The amount present in milk is influenced by the intake of the mother: if her diet is deficient in vitamin C, her breast milk will also contain a small and sometimes an inadequate quantity, as happened during the World War in Germany and Austria, where scurvy was observed in breast-fed infants. Under ordinary circumstances human milk contains enough vitamin C to prevent scurvy; increasing the amount in the mother's diet beyond a certain threshold level will not further raise its concentration in her breast milk. Fresh cow's milk at any season of the year usually has enough of the vitamin to prevent scurvy when fed in the quantities recommended for infant feeding; but the heating and ageing to which most milk is subjected in transit from cow to consumer permits a large part of its vitamin C content to be destroyed.

There is evidence that some of the vitamin ingested is destroyed in the alimentary tract. The fate of the portion absorbed is not yet well known, but it is certain that storage is limited. Experimental animals previously fed large amounts of vitamin develop scurvy quite as rapidly as controls when placed on a scorbutic diet.



On normal diets only a small fraction of the ingested vitamin appears in the urine, its concentration there being relatively constant.

In scurvy the excretion of ascorbic acid in the urine diminishes or even disappears, and the concentration in the tissues is likewise greatly decreased or even zero.

**Incidence.**—From the foregoing facts it is easy to understand the circumstances under which scurvy develops in early life. It is seen in infants fed exclusively on boiled or pasteurized milk. Since heating is a prerequisite for drying or evaporating milk, an exclusive diet of these products is equally dangerous. Scurvy occasionally develops on raw milk, usually when very dilute feedings are used; in this country it is rare in breast-fed infants. Hydrogen peroxide, once used as a preservative for milk, was a flagrant cause of scurvy. Proprietary foods and liberal carbohydrate additions to the milk formula increase the risk of scurvy, for less vitamin is ingested with the milk. Under any of these circumstances the disease is likely to develop unless antiscorbutic vitamin is supplied independently. The introduction of pasteurized milk brought about an increase in the disease, but fortunately this has now been followed by an enlightened propaganda, and few infants are now fed on boiled or pasteurized milk who do not receive their quota of orange juice or some other antiscorbutic substance. Most cases of scurvy are seen during the latter part of the first year; before six months and after fifteen months of age the disease is rare. The very young infant is perhaps protected by a store of vitamin acquired in intra-uterine life; furthermore he rarely suffers a complete privation of vitamin C and the disease is consequently slow in manifesting itself. Although scurvy may develop in six weeks in the complete absence of vitamin C from the diet, there is usually sufficient antiscorbutic to delay the onset from four to nine months after the poor diet has been inaugurated. The youngest patient seen in the Harriet Lane Home was four months old. After the age of ten or twelve months scurvy becomes increasingly rare, since a more liberal diet is then given. The cases in older children in this country are usually the result of food fads; Chick and Dalyell reported 40 cases in Vienna due to abnormal economic conditions following the World War.

Scurvy is often associated with rickets, a fact which is not surprising, since defective diets are responsible for both diseases; there is no reason for believing that the two diseases are related. Scurvy is more common in the winter and spring, since cows are less likely to receive fresh fodder then; the seasonal incidence is not so marked as in the case of rickets.

There can be little doubt that some children are more susceptible than others. One child develops scurvy even if a moderate amount of orange juice has been given; another child fails to develop it although fed for eight or nine months on boiled milk with no additional antiscorbutic. A number of instances have been observed in which one twin developed the disease, while the other twin, fed identically, remained healthy. The nature of this constitutional factor is obscure; it may be related to the excretion or the destruction of vitamin in the body. Recent studies have suggested that many artificially fed infants previously regarded as entirely healthy are actually in a state of subclinical vitamin C deficiency.

**Pathology.**—The essential nature of the pathological process in scurvy is not clearly understood. Höjer has described in experimental animals a degeneration



of the collagen fibers of connective tissue, affecting the whole body; he has also reported parenchymatous changes in many organs and tissues. These findings have yet to be confirmed in human scurvy. Lesions in man are recognized only in the bones and in the blood vessels; in the latter they consist of capillary hemorrhages, for which no anatomical basis is visible. Wolbach and others have attributed them to defects of the intercellular cement substance.

The changes in the bones are characteristic; they are most pronounced in the region where endochondral ossification is going on. The zone of proliferative cartilage becomes inconspicuous; few mitoses are seen among the cartilage cells, and they show little tendency to arrange themselves in orderly columns in the neighborhood of the epiphyseal line. Provisional calcification is not interfered with, but there is difficulty in converting the calcified cartilage into bone, owing to diminished activity of the osteoblasts. The zone of provisional calcification—the epiphyseal line—is broader than normal, because it is not destroyed; it is irregular, and less vascular than the normal. Beneath this broad zone of provisional calcification there is found an area of weak bone, which shows a characteristic lack of density by roentgenogram. This is known as the scurvy line (German, *Trümmerfeldzone* or “zone of confusion”). Trabeculae of bone, although present, are thin and scarce here; there are few evidences of osteoblastic activity; such osteoblasts as are found seem to be degenerate and resemble connective tissue cells. The marrow between the trabeculae has lost the appearance of normal lymphoid marrow; it is known as “framework marrow” (*Gerüstmark*) and consists chiefly of connective tissue.

Bone changes are not confined to the regions of endochondral ossification; atrophy of the trabeculae can be detected throughout the shafts of the long bones; periosteal ossification also shows abnormalities. Small hemorrhages are met with in the framework marrow; larger subperiosteal hemorrhages are found in the more advanced cases. A subperiosteal hemorrhage apparently starts close to the epiphyseal line and extends along the shaft of the bone, stripping off the periosteum as it goes; it never spreads in the other direction beyond the epiphyseal line; the perichondrium is never separated from the cartilage.

Epiphyseal separations are common in scurvy; often they are incomplete. Curiously enough, the separation does not necessarily take place through the zone of rarefaction below the epiphyseal line; cleavage sometimes occurs through the broadened zone of provisional calcification, suggesting that this may be brittle, although densely calcified. In view of the extensive bone changes, it is not surprising that the growth of bone is interfered with to some extent.

The bone lesions of scurvy are diffuse, although the process is likely to be more intense in places where bone is being more rapidly formed. Subperiosteal hemorrhages, too, are likely to be found in regions of rapid bone growth, although this does not invariably hold true. The most frequent sites are the lower end of the thigh, the lower end of the leg bones, the upper end of the thigh, the arm bones (especially the upper end of the humerus) and the skull. Multiple gross hemorrhages are not uncommon; quite often they are symmetrical. Extravasations are often found in the muscles and fascia in the region of a subperiosteal hemorrhage. Hemorrhages in the gums are common and are of great diagnostic importance; they are sometimes present even before the teeth have erupted.



Among the rarer manifestations of scurvy may be mentioned hemorrhage into the orbit; this occurred twice among 200 cases seen in the Harriet Lane Home. It gives rise to marked exophthalmos and sometimes chemosis and edema of the lids; often there are subconjunctival hemorrhages as well. Hemorrhages beneath the periosteum of the clavicles, the scapulae or the ribs may occur. The small bones of the body are almost never the seat of hemorrhage. Visceral lesions are infrequent; there may be small hemorrhages beneath the pleura, pericardium and peri-



FIG. 25.—FEMUR SHOWING SUBPERIOSTEAL HEMORRHAGES IN SCURVY OF SEVEN WEEKS' DURATION.

Death from bronchopneumonia and dysentery.

toneum; hemorrhagic effusions into the serous cavities do not, however, occur. The joints usually escape entirely, in spite of the striking lesions adjacent to them. Cutaneous ecchymoses or hemorrhages in any of the mucous membranes may be seen at times; there may be microscopic bleeding from the urinary tract, rarely from the gastro-intestinal tract, but gross hemorrhage in either place is rare. Intracranial hemorrhage occurred once in more than 200 cases seen at the Harriet Lane Home; it is the only complication of scurvy which is to be dreaded.

The hemorrhagic tendency in scurvy cannot be attributed to any defect of blood coagulation. It is regarded as due to alterations in the blood vessel walls.

Other deficiency diseases are not uncommonly associated with scurvy. The



presence of rickets complicates the picture in the bones and sometimes makes its interpretation difficult.

**Symptoms.**—In most cases a period of indisposition, fretfulness, pallor and loss of appetite precedes the local symptoms; as a rule this is not noticed at the time and is recalled only in retrospect. The first symptom to attract attention is usually tenderness of the legs. This may begin insidiously; at first it may be so slight as only to cause the patient to cry upon being handled; in other cases there is a sudden refusal to sit or stand. At first the tenderness is not definitely localized, but is generally more marked about the knees and ankles. It may be first noticed when the diaper is being changed or when the infant is lifted out of his bath. Some swelling may accompany it. Hemorrhage in regions other than the lower extremities may mark the onset of the disease. Changes in the gums are commonly found in the early stage, although they are rarely the first symptom to attract attention.

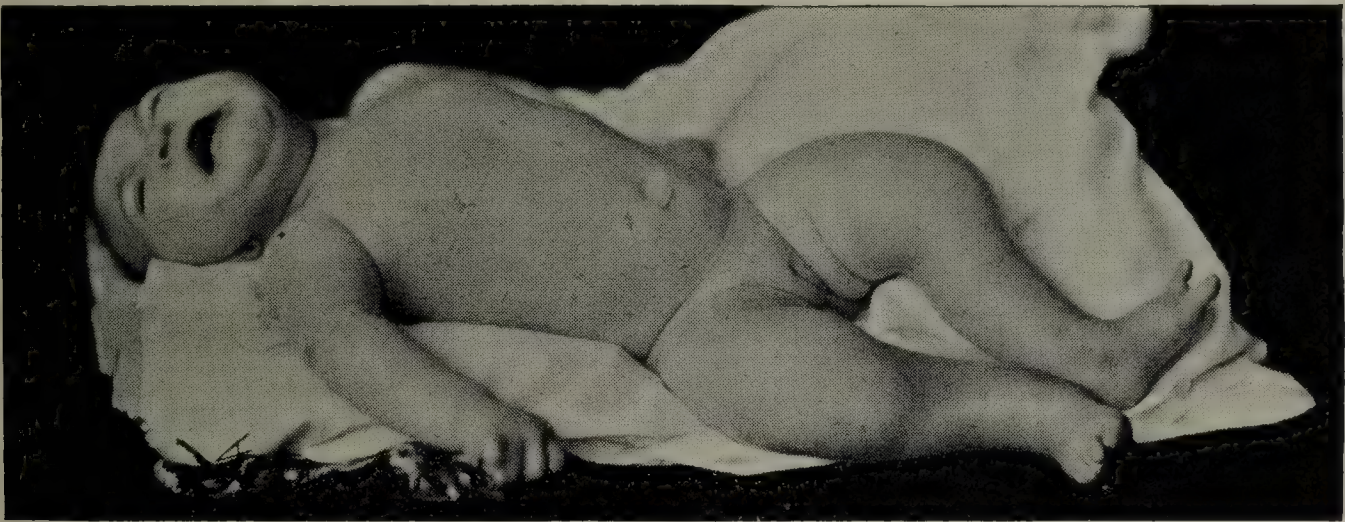


FIG. 26.—SCURVY SHOWING CHARACTERISTIC SWELLINGS AND POSTURE.

Patient eight and a half months old, fed exclusively upon malted milk after age of three months. Epiphyseal separation at the upper extremity of both humeri, lower extremity of both femora and lower extremity of left tibia. Prompt and complete recovery.

The amount of constitutional disturbance is most variable. There may be marked fretfulness, poor sleep, pallor, anorexia and loss of weight; in other cases symptoms of scurvy may continue for several weeks without making any perceptible impression upon the child's nutrition. In most of the cases seen in this country the onset is insidious, since it rarely happens that the diet is completely defective in the C factor. There may be periods of a few days with apparent improvement, which are perhaps due to variations in vitamin intake. Severe scurvy develops only when the condition is unrecognized and allowed to progress. Cases of fulminating scurvy, in which the disease develops with great rapidity and is unusually severe, are occasionally met with in this country; they were not uncommon in Europe during and following the Great War; they are apparently due to complete deprivation of vitamin.

In the more severe forms of scurvy, fever is usually present; the temperature is often as high as  $102^{\circ}$  or  $103^{\circ}$  F. ( $38.9^{\circ}$  or  $39.4^{\circ}$  C.). Tenderness in the legs becomes constant and is often exquisite, so that any movement or even the slightest touch causes the child to scream with pain or apprehension. The posture is characteristic. There is semiflexion of the thighs and legs and outward rotation of



the hips (Fig. 26). In this position the child often lies motionless, and voluntary movements of the extremities cannot be elicited. The disability results chiefly from the pain which motion provokes. In some instances, however, pseudoparalysis is out of proportion to pain and tenderness; in such cases the disability may be due to separation of the epiphysis. Small and sometimes large ecchymoses are frequently seen about any of the large joints, resembling ordinary "black-and-blue"

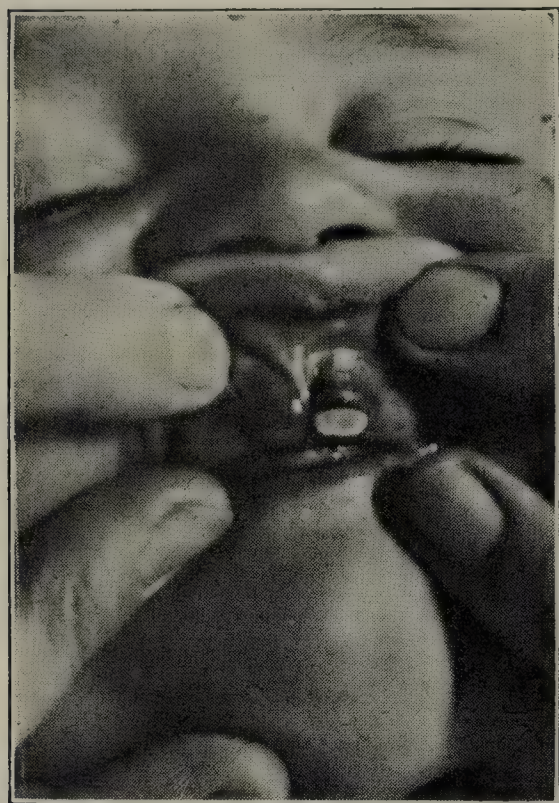


FIG. 27.—GUMS IN SCURVY.

spots, and these often confirm the opinion previously formed that the child has met with some accident. The swelling of the joints, particularly the knee, may be so great that the limb is nearly twice the size of its fellow. In thin patients a purplish tint, independent of ecchymoses, may suggest the hemorrhagic nature of the swelling. Although the swelling is principally due to subperiosteal hemorrhage, some brawny edema is commonly present in the extremities; it does not pit readily on pressure.

Epiphyseal separation is seen in most of the severe cases; it is sometimes only partial and unaccompanied by displacement. It occurs most frequently either at the lower epiphysis of the femur or tibia, or the upper epiphysis of the humerus; it is often bilateral. Although the condition of the bone is a predisposing factor, a slight trauma is usually the immediate cause. Crepitus is obtained only with

complete separation and with unwarranted manipulations. The diagnosis can readily be made by x-ray, or by the persistence of local pain more than two or three days after the onset of treatment. Not infrequently there are associated subperiosteal impacted fractures of the shaft of the long bones, close to the epiphyseal line.

The buccal symptoms are rarely prominent unless the teeth have erupted or are about to erupt. Often the gums of the upper jaw alone are involved, those about the upper central incisors being most commonly affected. The gums are swollen, livid and bleed easily; dark purplish bags may cover teeth not yet erupted. In the most marked cases the gums may ulcerate, the appearance resembling a mercurial stomatitis. Pain from sore gums may seriously interfere with taking of food. The teeth themselves show histologic changes analogous to those described in developing bone; the lesions are by no means confined to peridental hemorrhages.

Among the less common sites of bone involvement in scurvy, the ribs should be mentioned. There may be merely a zone of tenderness along the costochondral junctions, but in some advanced cases there is epiphyseal separation of several of the upper ribs, so that the whole chondrosternal plate is displaced backward by atmospheric pressure. The sharp, projecting ridges of the ends of the ribs may be readily felt with the examining finger, this "scorbutic rosary" in most cases being easily distinguished from the more common beaded rosary of rickets. Lesions in the orbit causing exophthalmos have already been mentioned.

Bleeding may occur from almost any of the mucous membranes; the hemor-



rhages are generally small, but may be frequently repeated. Bleeding may come from the roof of the mouth or the nasopharynx, less commonly from the stomach or bowel. The presence of blood and mucus in the stool should suggest dysentery in addition to scurvy; commonly enough both conditions are present. Microscopic blood in the urine occurred in about one-third of our cases; gross hematuria is less common. In some of the patients with hematuria, albumin and casts are present as well and usually lead to the diagnosis of hemorrhagic nephritis; the condition disappears, however, shortly after treatment is started.

Petechiae and ecchymoses in the skin are more common in the vicinity of the gross bone lesions; widespread petechial eruptions are sometimes seen. If there is a superimposed skin disease associated with scurvy, such as measles, varicella or furunculosis, the lesions are usually hemorrhagic. Hess has called attention to the frequency of miliaria in scurvy. The blood picture in early scurvy may be normal despite the presence of pallor. Later, a secondary anemia may develop and the hemoglobin may fall as low as 35 or 40 per cent. There are no characteristic changes in the leukocytes. Studies of the blood chemistry have shown normal values for calcium and inorganic phosphorus.

A typical history of a moderately severe case of scurvy is given below:

William W., eleven and one-half months of age on admission, had been a small child at birth, weighing only  $5\frac{1}{2}$  pounds. He was nursed for three months and was then put on formulas containing pasteurized milk, water, and cane sugar. Orange juice had been given only occasionally, and cod liver oil was not started until one week before admission. He had had bronchopneumonia at about six months of age and was somewhat subject to colds. Otherwise, his health had been good and his mental and physical development normal.

Four weeks before admission the mother noticed that the patient was becoming pale and sickly and disliked being touched. At the same time a small "blood gum boil" was discovered above one of the upper incisor teeth. Shortly after this the child refused to stand on his feet when held by the arms. Twelve days before admission he fell backward on a couch and as a result seemed to be in great pain. The following day both thighs were found to be distinctly tender and a surgeon was consulted, but he found no evidence of trauma. After another four days the right thigh became swollen; x-ray examination then showed displacement of the lower epiphysis of the right femur and a cast was applied. The patient's general condition, however, did not improve and he was brought to the pediatric dispensary.

He weighed only 14 pounds, 13 ounces, and had a temperature of  $99.8^{\circ}$  F. The diagnosis of scurvy was evident from the presence of hemorrhages into the gums with oozing of blood around the upper incisors, pseudoparalysis of the lower extremities, which were held in the typical scorbutic attitude of partial flexion of the knees with marked external rotation of the thighs, tenderness and swelling of the right thigh, localized around the lower end of the femur and extending well up toward the center of the bone, and brawny edema of both legs and of the right thigh. The epiphyses at the wrists and ankles were enlarged. There was a marked rosary with posterior displacement of the entire sternum and attached costal cartilages—changes which might have been due either to scurvy or rickets or to a combination of the two. There was marked secondary anemia. Both the liver and spleen were slightly enlarged. The blood Wassermann reaction was negative. The serum calcium was 12.0 milligrams per 100 c.c.; the inorganic phosphate, 5.1 milligrams per 100 c.c. The urine was normal and the intracutaneous tuberculin test negative to 0.1 milligram of tuberculin.

For the first day he was given an ounce of orange juice every two hours, thereafter half an ounce three times a day. He took also three teaspoonfuls of cod liver oil a day.



The diet for two days consisted of a boiled milk formula; thereafter he received a mixed diet suitable for a child of one year of age. Subjective improvement began to be noticeable on the first day, and after the second day the swelling of the gums and of the right thigh receded appreciably. He lost weight for about two weeks, but commenced gaining after a transfusion of blood. Further convalescence was uneventful. At the age of two years he weighed 25 pounds.

The data of McLean and McIntosh from cases seen at the Babies' Hospital give an idea of the frequency of the various clinical manifestations of the disease. Fever was present in 75 per cent of the cases. Tenderness in the extremities was conspicuous in 84 per cent, and swelling in 71 per cent. The scurvy posture was noted in 57 per cent, and pseudoparalysis in 14 per cent. Approximately two-thirds of the patients showed changes in the gums. About one-third showed hemorrhages in the skin and an equal number showed at least microscopic hematuria. Subperiosteal hemorrhages involving other bones than those of the extremities occurred in 16 per cent of the cases.

**Roentgenographic Appearances.**—In cases of scurvy with extensive subperiosteal hemorrhages, a striking x-ray picture is disclosed when the healing process causes bone formation to be resumed in the elevated periosteum. Of greater diagnostic importance are the changes met with in the early stages of the disease. Although attention was called to these by Fraenkel in 1908, it is only within the last decade that their importance has been generally appreciated. By means of the x-ray it is frequently possible to make the diagnosis of scurvy before the development of hemorrhages. The changes characteristic of early scurvy are: (1) A "*ground-glass appearance*" of the shaft,<sup>2</sup> due to atrophy of the trabeculae. Individual trabeculations are made out with difficulty or not at all, in sharp contrast to the picture found in active rickets in which the shaft presents great irregularities in density. The cortex may be thinned out. (2) A *broadened epiphyseal line* (the zone of provisional calcification) is conspicuous, particularly at the lower end of the femur and at both ends of the tibia; it may be finely irregular. (3) Beneath the broad epiphyseal line is a *zone of rarefaction* corresponding to the Trümmerfeldzone or scurvy line. This zone is narrow and difficult to detect in early scurvy in contrast with the somewhat similar rarefied zone sometimes seen in early healing rickets and in early syphilis. In more advanced cases of scurvy this line is broader. These same features can be made out in the epiphyseal centers of ossification: the ground-glass appearance, the dense epiphyseal line appearing as a ring surrounding the epiphyseal center, most dense on the side toward the bone itself. The rarefied zone beneath this ring may be difficult to detect.

In well-developed clinical cases of scurvy these changes are all more prominent and other signs also appear. Displacement of the epiphysis is indicated by faulty alignment of the epiphyseal line with the shaft of the bone; there is a lateral projection of the shadow caused by the epiphyseal line. Even more common is a partial separation of the epiphysis occurring without displacement. This appears as a crack separating the epiphyseal line from the shaft and extending part way across the width of the bone. After hemorrhage has occurred, the first evidences of calcification of the hematoma are seen as spurs attached to the

<sup>2</sup> This feature may be wanting in the fulminating cases of scurvy.



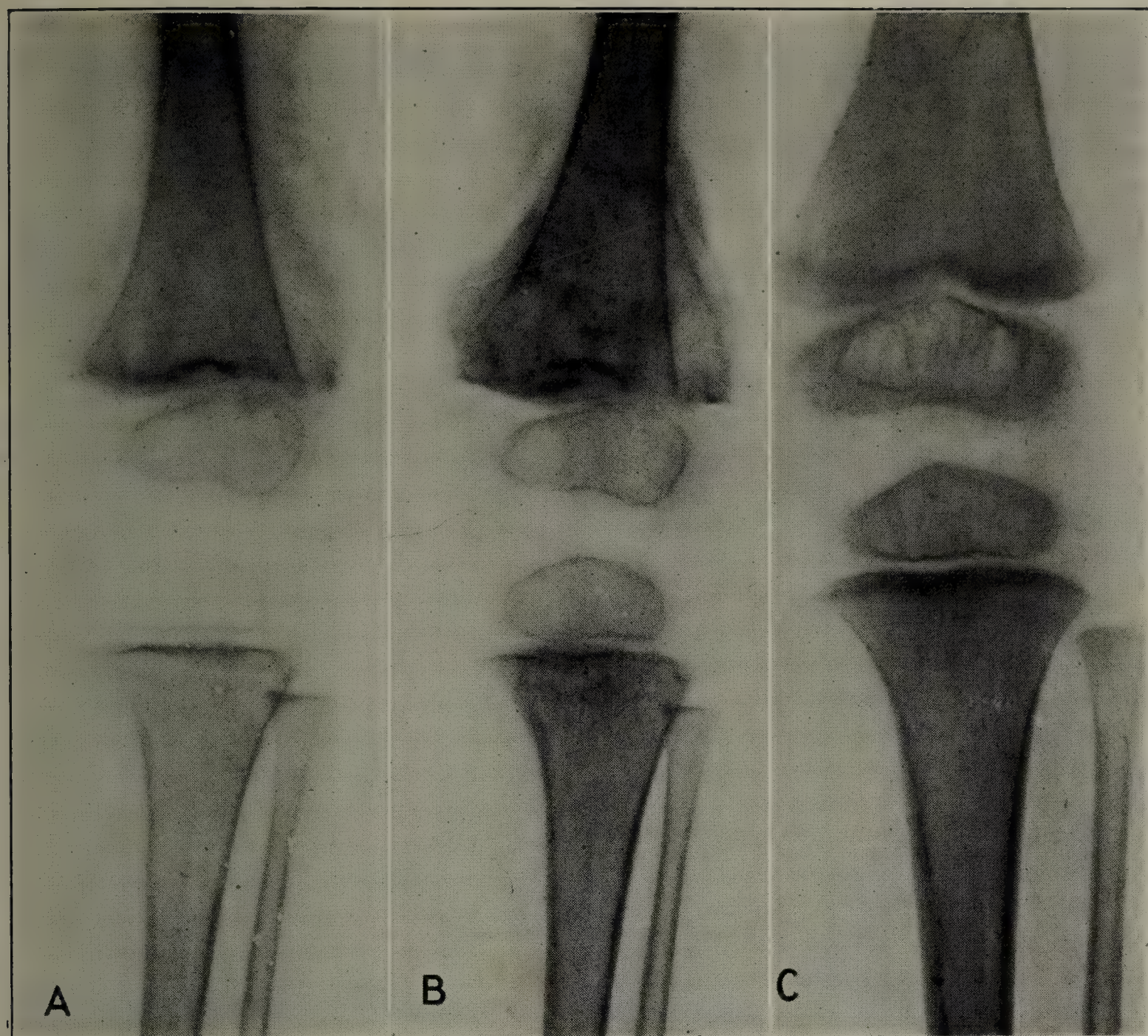


FIG. 28.—ROENTGEN-RAY CHANGES IN SCURVY.

A. ACTIVE SCURVY, showing trabecular atrophy and thinning of the cortex, prominence and thickening of the zone of preparatory calcification, and exaggeration of the periphery of the centers of ossification, with rarefaction of the interior. In the tibia a faint zone of rarefaction is visible beneath the zone of preparatory calcification. In the femur the zone of preparatory calcification overlaps the metaphysis, giving rise to scorbutic "spurs." Prominence of the spur on the lateral side of the femur is here partly the result of epiphyseal separation, with lateral shifting of the center of ossification, the epiphyseal cartilage and the zone of preparatory calcification. In the tibia there is a partial or "subperiosteal" fracture with comminution on the medial side of the metaphysis. Calcification of elevated periosteum at the lower end of the femur is just beginning to appear.

B. HEALING SCURVY WITH CALCIFICATION BENEATH THE ELEVATED PERIOSTEUM. The same bones four weeks later, showing an increase in density everywhere except at the interior of the centers of ossification. The outline of the elevated periosteum, which during the acute phase was ballooned out by the underlying hemorrhage, has contracted down appreciably during the healing process.

C. RESIDUAL CHANGES IN HEALED SCURVY. The same bones fourteen months later, with the centers of ossification showing the characteristic kernel of rarefied trabecular bone surrounded by normal bone. The evidences of scurvy have practically disappeared from the shafts.

The patient was fifteen months old on admission. One month before admission, the left leg had been put in a plaster cast for supposed anterior poliomyelitis; more recently the right leg had also become tender. Temperature 102.4° F.; left lower extremity held in typical scorbutic attitude, the "frog position"; swelling of lower part of left thigh and left leg, with tenderness of both lower extremities; hemorrhages in the gums; miliaria; microscopic hematuria. The first roentgenogram, taken one week after admission, shows all the characteristic roentgenographic changes of the acute stage, with, in addition, evidence of beginning healing.



epiphyseal line, pointing toward the shaft of the bone or somewhat outward if the hemorrhage has been a large one.

When scurvy heals, the scurvy line (*Trümmerfeldzone*) becomes filled with normal dense trabeculae; in fact, for a time it becomes unusually dense and forms a shadow which fuses with the epiphyseal line. With growth of the bone, this shadow gradually becomes incorporated in the shaft, but remains visible for some time as a transverse line. Calcium is deposited as new bone is formed by the elevated periosteum, showing in the course of a week or two of healing the full extent of periosteal stripping. As the subperiosteal hematoma resorbs, the periosteal bone outline contracts and becomes denser, at times obscuring the cortical outlines and marrow canal. Where considerable epiphyseal displacement has taken place, a new marrow cavity may eventually be carved out to correspond with the shift of the longitudinal axis of the bone. Eventually the shaft resumes its normal appearance, but these changes may occupy a year or more.

In the absence of rickets, scurvy can be recognized with ease by one who is familiar with its roentgenological appearances. The difficulties concern cases in which the two diseases coexist.

**Diagnosis.**—This seldom presents any obstacle to one who has once seen a case. No one need err if the essential features are kept in mind: the age incidence, the extreme tenderness of the legs, spongy swollen gums, swelling near the large joints, a tendency to hemorrhages, and usually a history of the prolonged use of boiled or pasteurized milk or some proprietary food. One should not be too easily misled by a parent's statement that orange juice has been given; a closer inquiry may reveal that it has been refused or vomited.

Scurvy is often confounded with articular rheumatism by those who are unfamiliar with the age incidence of the two diseases. Cases with pseudoparalysis may be mistaken for poliomyelitis. Hyperesthesia is rarely as marked in poliomyelitis as in such cases of scurvy; the reflexes persist in scurvy, and painful stimulation of the extremities will usually indicate that actual paralysis is not present.

We have known two patients with scurvy to be operated on by eminent surgeons, once with a diagnosis of malignant disease, and once of osteitis of both tibiae. In cases with considerable fever, scurvy may be mistaken for acute arthritis or epiphysitis due to pyogenic organisms. Pyogenic infections are rarely bilaterally symmetrical, they are accompanied by leukocytosis, and the swellings may fluctuate, pus being found on aspiration; the x-ray is of great diagnostic help in confusing cases.

The osteochondritis of early congenital syphilis has many symptoms in common with scurvy; the x-ray appearances present some similarity at times. Syphilitic osteochondritis, however, is seen at an early age, almost always less than four months, while scurvy occurs after this time.

Hematemesis from scurvy has led to a mistaken diagnosis of gastric ulcer. Loss of blood from the intestine may suggest intussusception. When hemorrhagic manifestations are absent, confirmatory evidence of scurvy may be obtained by the Rumpel-Leede phenomenon. The sign is nearly always positive in scurvy, but is not pathognomonic. It occurs also in purpura, scarlet fever, leukemia and



other conditions. On obstructing the venous return from an extremity for two or three minutes with a tourniquet, petechial hemorrhages appear in the extremity.

The most difficult cases of scurvy to recognize are those in which there

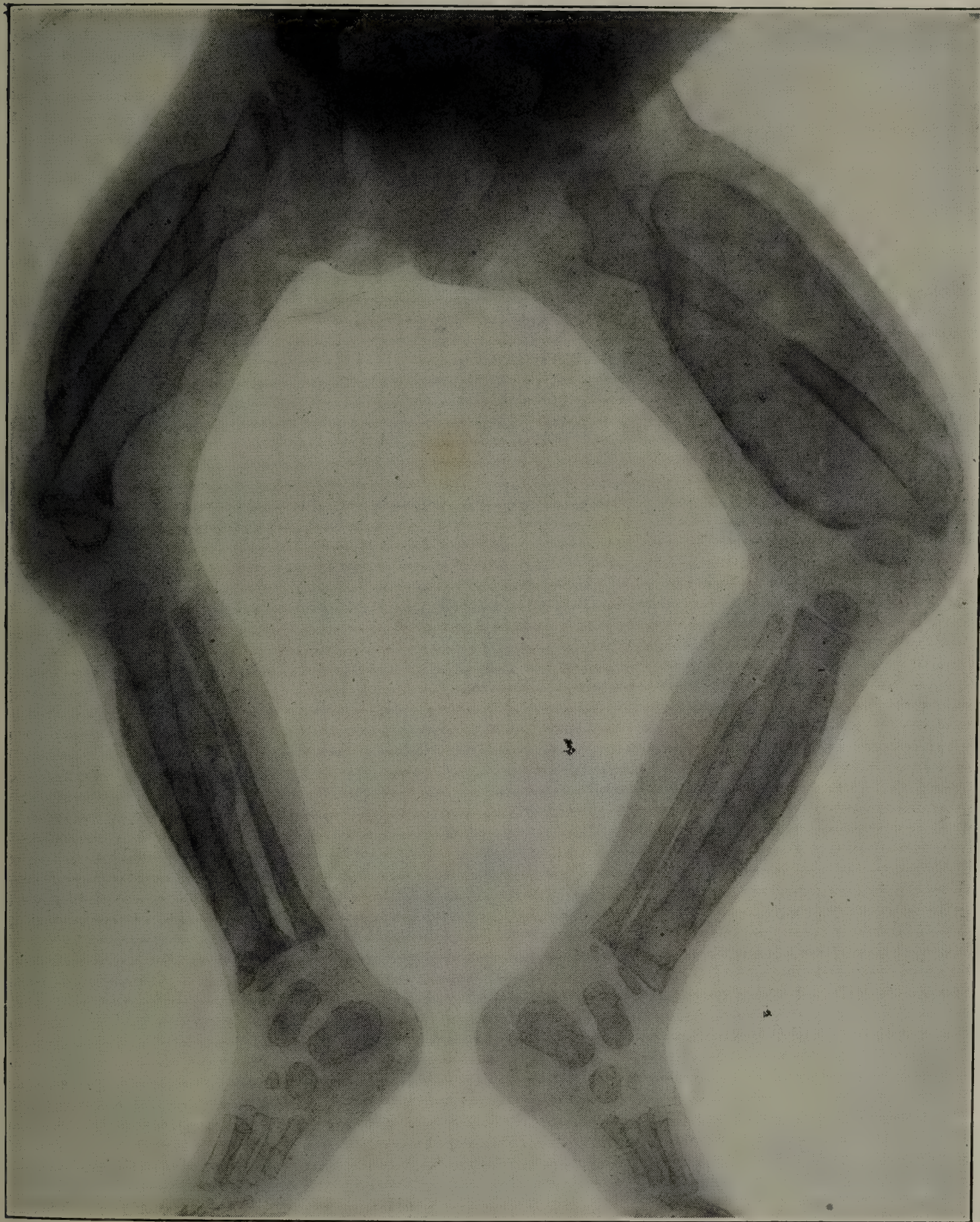


FIG. 29.—ROENTGENOGRAM IN SEVERE SCURVY, IN HEALING STAGE.

Large extravasations about both femora and tibiae; separation and dislocation of both lower femoral epiphyses.

are no clinical manifestations in the extremities. Sharp roentgenograms may be of great help in the hands of an experienced interpreter, since the x-ray changes usually antedate the local symptoms. Often, doubt will be entirely removed by prompt improvement under antiscorbutic treatment.



**Treatment.**—To protect against the development of scurvy, every infant who is even partially dependent on boiled, pasteurized, dried or evaporated milk should be given some antiscorbutic food as early as the first or second month. Orange juice is the most convenient of these; one teaspoonful daily should be given at first and the amount increased to the juice of one orange as soon as the digestion will permit. The minimum protective dose is about one tablespoonful a day. The juice of lemon or grapefruit is quite as effective, but more difficult to administer separately. All fresh fruit juices have antiscorbutic properties; prune juice is, of course, not included in this category. One of the most satisfactory antiscorbutics is the juice of fresh or canned tomatoes; this should be strained and given in doses twice as large as those advised for orange juice; sometimes it causes looseness of the bowels. There is no objection to giving fruit juices or tomato juice in boiled milk, provided it is added after the milk has been cooled. Other foods which have noteworthy antiscorbutic properties are the raw juice of the yellow turnip (swede) and fresh cabbage. Cooked green vegetables and potato contain the vitamin in small amounts. Banana and other artificially ripened fruits are not reliable sources.

The treatment of a child who has developed scurvy is usually a simple matter. Orange juice should be given in doses of four ounces (120 c.c.) or more a day. The only difficult cases are those in which gastro-intestinal disturbances are present. Diarrhea is not a contra-indication for giving orange juice; we have seen instances of persistent diarrhea clear up so promptly after giving orange juice as to suggest that the symptom bore some relation to scurvy. When orange juice is persistently refused, one may give pure ascorbic acid by mouth in doses of 100 milligrams daily. It is doubtful whether larger quantities materially hasten recovery. Goettsch has shown that the entire dose required for maximal healing over a period of eight days may be administered at one time. In the presence of severe vomiting, ascorbic acid may be injected intravenously.

Local treatment of the extremities is not generally required.

**Course and Prognosis.**—Fatal scurvy is now rarely seen. It is only in neglected cases with severe malnutrition or digestive complications that the issue becomes doubtful. Secondary infections, like pneumonia, may cause death; in one of our patients death resulted from hemorrhage following incision of an epiphyseal swelling, the bleeding persisting in spite of treatment.

The results of treatment are usually prompt and may be dramatic. Within the first twenty-four hours changes in the disposition and appetite are usually noticeable. The prompt disappearance of tenderness from the extremities is singularly striking and has never been satisfactorily explained. Persistence of the tenderness suggests separation of the epiphysis. Hemorrhage is not likely to occur at new sites after the first few hours of treatment, but it is not uncommon for bleeding to continue for a few days from the gums or elsewhere. When the swelling of the gums subsides, a new tooth may be found to have erupted. Hematuria has been known to persist for as long as two weeks, but large hemorrhages either from the kidney or the gastro-intestinal tract usually cease promptly. Fever seldom persists more than two or three days. Sometimes malnutrition persists as a serious problem; in such cases transfusion may be of help. Loss of



weight during the first few days of treatment is by no means unusual, owing to disappearance of edema that may be present.

The repair of the bone lesions begins at once, although a week or more is required before improvement can be detected by x-ray. One of the earliest changes seen is new calcification as periosteal bone production is resumed. The elevated periosteum gradually contracts down as the hemorrhage beneath it is absorbed. Even after marked displacement of the epiphysis the alignment between the shaft and the epiphyseal fragment is gradually restored with the growth of the bone. Roentgenological evidences of scurvy may be recognizable years later in the form of a prominent transverse line buried in the shaft which once represented the broad epiphyseal line of acute scurvy; the circular or oval area of rarefied trabecular bone which once comprised the scorbutic center of ossification may persist, buried in the middle of a center which has grown much larger. Permanent deformities resulting from scurvy, however, are exceedingly rare.

Improvement under treatment is usually continuous. Relapses, when they do occur, are occasioned by acute disturbances of digestion.

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## CHAPTER XXV

### RICKETS

Rickets is a general disorder of metabolism, affecting chiefly the bone-forming minerals—calcium and phosphorus; its most striking manifestation is poor calcification of the bones. Although the only characteristic lesions are those of the bones, the muscles and ligaments are also involved, and the disease should doubtless be regarded as one which affects the body as a whole. Rickets is perhaps the most common disease of early childhood. As the result of the great advances of recent years, there are now few diseases which are better understood.

**Etiology.**—Among the deficiency diseases, rickets is unique in that a dual deficiency must exist before it can develop; the intake of vitamin D must be inadequate and the body must receive insufficient exposure to ultraviolet rays. If either one of these factors is adequately supplied, rickets fails to develop; either one alone is capable of effecting a cure. A knowledge of these two factors explains the incidence of the disease.

*Antirachitic Radiations.*—Sunlight contains the effective antirachitic rays and rickets owes its origin in large measure to inadequate exposure to the sun, as was clearly appreciated by Palm in 1890. The effectiveness of the sun's rays is considerably diminished by their passage through the atmosphere. Interference from this source is least at high altitudes and when the sun is at the meridian; when the sun's rays come at an oblique angle, as they may at certain seasons and at certain times of day, even a prolonged exposure may be ineffective. Dust and smoke interfere with the passage of the rays. The effectiveness of radiation is influenced by the clothing—the greater the area exposed, the greater the effect. It is also influenced by pigmentation of the skin, penetration occurring less readily through a dark skin. Ordinary window glass prevents the passage of ultraviolet rays almost completely, but special glasses have been devised that transmit variable amounts. Tisdall has emphasized the fact that “sky shine”—sunlight reflected from clouds—contains effective ultraviolet rays. Many lamps are available which generate sufficient ultraviolet radiation to cure or prevent rickets. The valuable portion of the spectrum is that between 260 and 315  $\mu\mu$ , the greatest effect being obtained with rays between 280 and 300  $\mu\mu$  in length. The best summer sunshine contains rays between 290 and 315  $\mu\mu$ ; in winter it may contain only rays longer than 307  $\mu\mu$ .

*The Dietary Factor—Vitamin D.*—It has been recognized for years that rickets was usually seen in artificially fed infants, most of whom received less fat and more carbohydrate than the breast-fed infant. Sweetened condensed milk and proprietary foods rich in carbohydrate seemed to predispose particularly to the disease. Although certain animal fats, notably fish oils like cod liver oil, had been regarded as valuable therapeutic agents, it remained for Howland and Park to



establish this beyond a doubt. The production of experimental rickets in animals by McCollum and his associates made it possible to study the distribution and nature of this food factor, which is now known as vitamin D. In natural products vitamin D is most abundant in fish oils; it is present in smaller quantities in egg yolk. Other animal fats such as lard, suet, or tallow have little or no antirachitic value, and the same may be said of vegetable fats. Cow's milk fat and breast milk fat both contain small amounts of this vitamin; the quantity is subject to great individual variations, some of which can be attributed to antirachitic factors in the diet or environment of the mother.

Following the discovery of Huldschinsky that rickets could be cured by ultraviolet rays, both Hess and Steenbock made the important observation that a variety of fat-containing foods could be given antirachitic properties by means of ultraviolet radiation. Subsequent work by Rosenheim and Webster, and by Hess and Windaus, indicated that this property was due to traces of ergosterol, a sterol widely disseminated in nature. Ergosterol itself is inactive, but when subjected to ultraviolet radiation it appears to be converted into an isomer which is an extraordinarily powerful antirachitic agent; preparations have been obtained more than 100 million times as potent as the average cod liver oil. The discovery of the extreme potency of activated ergosterol led to the belief that this substance was in reality Vitamin D itself, and that all antirachitic substances owed their activity to its presence in small amounts; the value of direct irradiation of the body was attributed to the activation of small amounts of ergosterol in the skin.

Recently evidence has been brought forward pointing to a multiplicity of antirachitic factors. Fundamental differences have been observed in the potency of cod liver oil, irradiated ergosterol and certain derivatives of cholesterol when used in different animal species; in the chick, for example, irradiated ergosterol is relatively ineffective as compared to cod liver oil and irradiated cholesterol given in dosages equivalent for the rat. It is not clear whether the rat units now used to standardize antirachitic products give a true indication of their relative potency in man.

*Growth.*—Whether or not the lesions of rickets will develop depends in large measure on the rapidity of growth. The development of poorly calcified bone, the characteristic feature of the disease, does not occur unless growth of bone is proceeding. Lesions of rickets are always most marked in the regions of most rapid bone growth. The underlying metabolic disorder in rickets is, of course, independent of growth, but growth determines the extent of the lesions. In the absence of growth the only change in the bones is osteoporosis.

*Other Contributory Causes.*—A number of other factors may be concerned in the production of rickets. They are of secondary importance only, because if sufficient vitamin D or irradiation is supplied they fail to produce rickets. These causes are significant only in borderline conditions. Among them may be mentioned the quantity of calcium and phosphorus in the diet, the ratio of these two elements in the diet, the acidity of the intestinal tract, and the reaction of the body fluids. An extremely low intake of calcium and phosphorus tends to favor the development of rickets. A marked excess of calcium over phosphorus or of phosphorus over calcium also does this. Increased acidity in the intestinal tract promotes absorption of these elements and, conversely, increased alkalinity



leads to precipitation of calcium phosphate in the intestine and favors the development of rickets. A chronic acidosis causes decalcification of the bones and interferes with calcification, tending to favor the development of rickets. Infections may promote the development of rickets, but often they cause an arrest of growth which prevents the development of rachitic lesions.

*Age Incidence.*—Active rickets is essentially a disease of the first two years of life. It is rare before the third month. The youngest case reported in this country is probably a child thirty-four days old observed by Dunham. Reports of congenital rickets are found in the literature. Most of them are instances either of osteogenesis imperfecta or of chondrodystrophy; two unquestionable cases of congenital rickets were, however, observed by Maxwell in China in infants whose mothers were suffering from osteomalacia. Between the fourth and the eighteenth month rickets is extremely common. After the second year rickets again becomes rare, for most children are then receiving a mixed diet with a liberal quantity of egg, they are out of doors frequently, and their rate of growth has become slower. Occasionally one sees rickets in children of four or five who have lived on very poor diets and under bad hygienic conditions. In older subjects it is seen in conditions of war and famine; during and following the Great War late rickets was observed in many parts of Europe.

*Geographical Distribution.*—Although the disease has been observed in almost all parts of the world, by far the greatest frequency is in the temperate zone. In tropical and semitropical countries rickets is rare because children are in the sun a large part of the time. In the polar regions the disease is uncommon, since fish oils form an important article of diet. The inhabitants of warm countries seem to suffer particularly when removed to the temperate zone. The explanation for this is probably that their dietary habits undergo little change for a generation or two, whereas the opportunities for effective exposure to the sun are greatly decreased. In New York rickets is seen particularly in Negroes and in immigrants from Mediterranean countries. Probably the pigmentation of the skin is partly responsible for this. At all events it is in these subjects that the most severe cases are met with.

Rickets is much more common in cities than in the country, since there are fewer opportunities for children to be out in the sunlight, and the sun's rays are more likely to be obscured by dust and smoke. Diet is likely to be better in the country; maternal nursing is more prevalent there.

*Frequency.*—The frequency of rickets in cities of the temperate zone is well attested by the pathological observations of Schmorl in Dresden, who found some years ago that the disease was well-nigh universal in infants coming to autopsy. At the present time, owing to the widespread use of preventive measures, its incidence is steadily decreasing. A recent study made by Park in Baltimore showed that in autopsies on infants between four and eighteen months of age rickets was present in 36 per cent of the white infants and in 62 per cent of colored infants.

*Season.*—The figures from four large outpatient clinics show that the disease is twice as frequent from January to June as from July to December. Active rickets is usually seen in the winter and spring months; in the summer and fall



healing rickets is ordinarily found. The seasonal variations in sunlight are responsible for these differences.

*Heredity.*—It has been claimed by Siegert and others that rickets is a hereditary disease. Siegert reported numerous instances in which children with rachitic parents developed rickets, while other children receiving the same food and living in the same environment failed to do so.

*Individual Susceptibility.*—Differences of susceptibility may be seen when no familial influence is demonstrable. Of two children under identical dietary and hygienic conditions one may develop rickets and the other escape it.

*Prematurity.*—It is a common observation that premature infants are prone to develop rickets early and severely. There are several possible reasons for this. In the premature infant the demands for calcification are relatively greater, since he is born with a relatively smaller part of the skeleton calcified. Moreover, growth in the premature is rapid. It is known that premature infants absorb fats poorly, and it is likely that they may not absorb vitamin D as well as normal infants. The frequent association of syphilis with rickets is probably due to the great number of syphilitic infants who are premature.

Other factors have been suggested as important in the etiology of rickets. Findlay and Noel Paton have emphasized confinement and lack of bodily activity as a factor. This view has not met with general acceptance. Although animals closely confined often develop great alterations in the bones, these are not true rickets.

*Pathology.*—The morphological changes in rickets are by no means confined to the bones. There is reason to believe that the disturbance of metabolism affects the muscles, ligaments and perhaps many other tissues. The parathyroid glands are regularly hypertrophied in animal rickets, and there is some evidence that this holds true for the human disease. It is only the bone lesions, however, which are sufficiently constant and characteristic to give rickets a place as a distinct disease.

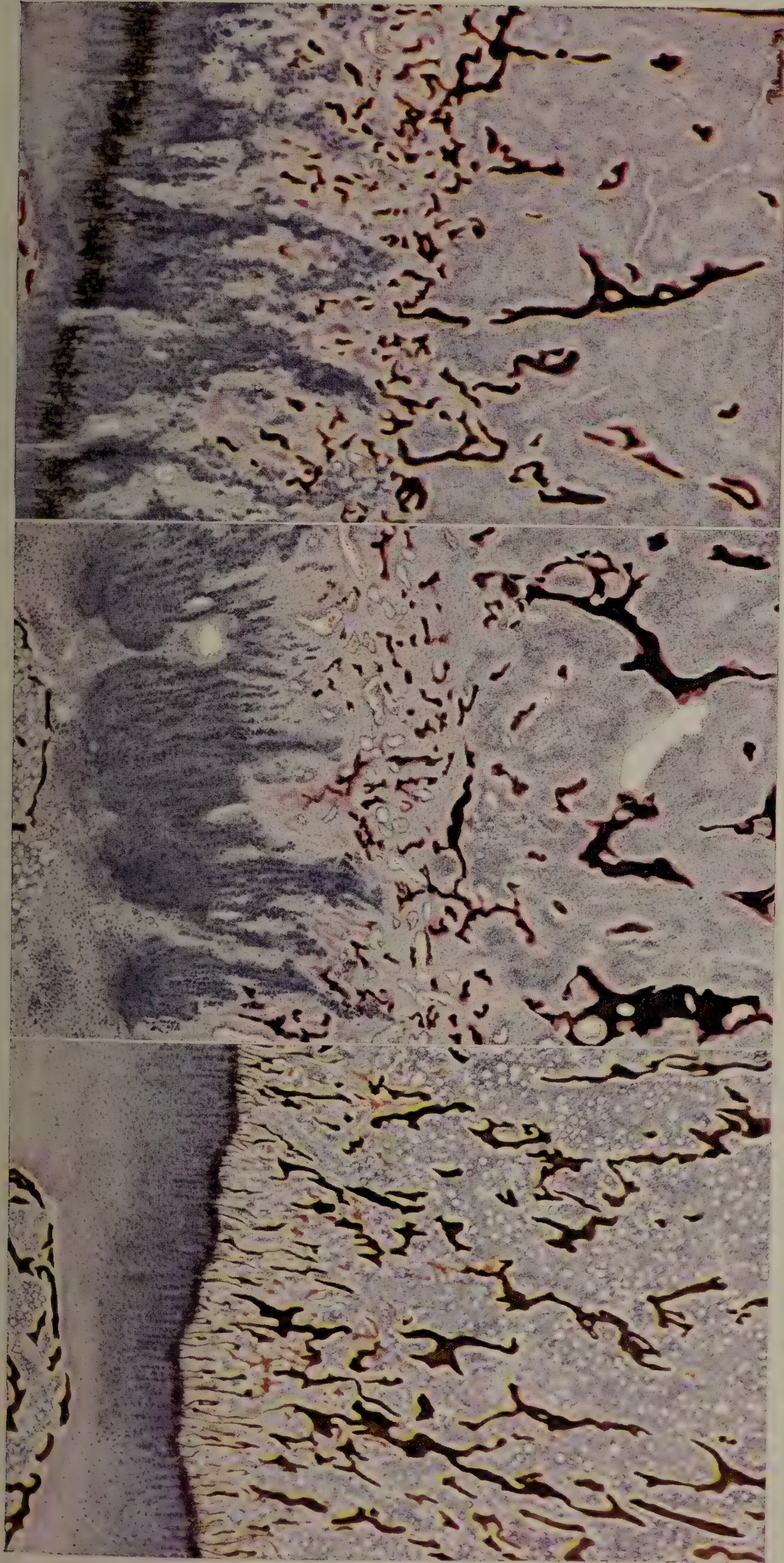
In the active stage of rickets, the mineral content of the bones is regularly decreased. Normally, bone contains about one-third organic and two-thirds inorganic matter. In marked rickets the proportions are reversed, the bones often containing twice as much organic as inorganic matter. Almost the entire loss is in the calcium phosphate, which normally constitutes about 85 per cent of the mineral matter; in rickets the ratio of phosphate to carbonate is decreased.

The anatomical changes are due partly to the low mineral content, which deprives the bone of much of its supporting framework. There are other changes, however, which are due to abnormal functioning of the cells engaged in the process of osteogenesis. This disturbance of function is doubtless due to the abnormal chemical environment; when the environment is restored to normal, normal cellular function is resumed.

*Gross Appearances.*—Rickets may affect nearly every bone in the body, both the long bones and the flat bones. When the changes are at all marked they are apparent in the gross. The most characteristic change in the long bones is enlargement of the epiphyses; curvatures and pathological fractures occur in the more severe cases. The epiphyseal changes are most marked in the regions of most rapid growth—the costochondral junctions of the middle ribs, the lower ex-



PLATE I



A

A, normal bone

B

B, active rickets

C

C, beginning healing of rickets

MICROSCOPIC APPEARANCE OF CARTILAGE-SHAFT JUNCTION.

The preparations are stained with silver nitrate, hematoxylin and eosin.







remities of the radius and ulna, the tibia and the fibula. The transitional zone between the cartilage and bone (the metaphysis) is much enlarged in width and thickness; on section it is of a whitish or bluish-white color, rather softer than normal cartilage. Characteristic deformities are produced by bending at this weakened point. Rachitic curvatures and fractures are allowed by a rarefaction of the bone with resulting diminution of mineral matter (osteoporosis) which affects both the cortex and the trabeculae. A compensatory thickening of the cortex can be seen in the gross in many cases of rickets. Curvatures result from muscular action, atmospheric pressure, abnormal postures, to the weight of the limbs or the weight of the body. The individual deformities are described under symptomatology. Fractures are usually of the greenstick variety. As a rule there is considerable callus formation, but sometimes this is wanting. The principal changes in the flat bones consist in the production of large bosses or prominences upon the frontal and parietal bones. Deformity occurs where the stress is greatest—at the points of normal curvature; it is confined almost entirely to the outer table of the skull. Beneath the periosteum there is a compensatory production of poorly calcified bone. The deficiency of lime salts over certain areas of the skull that are thin even under normal conditions allows them to be indented with the finger (craniotabes).

*Microscopic Appearances.*—The changes seen in rickets can be understood only if the picture of normal ossification is kept in mind. When normal conditions prevail at the epiphyses, on approaching the epiphyseal line from the cartilage it is noticed that the cartilage cells become more mature; they stain deeply with hematoxylin and arrange themselves in columns parallel to the long axis of the bone. Between these columns is an amorphous intercellular matrix which becomes calcified (primary or provisional calcification) when it is approached by the budding marrow vessels. The rigid columns of calcified matrix seem to direct the invading marrow vessels, and the transformation of cartilage into bone proceeds in an orderly manner. The line of ossification extending across the shaft is straight and regular. On the one side we find parallel columns of cartilage cells and calcified matrix, and on the other we find that the spicules of calcified cartilage have passed over into trabeculae of true bone (secondary or permanent calcification) and in place of the columns of cartilage cells we find marrow capillaries surrounded by osteoblasts. Just how this transformation is brought about is not clear. It is usually stated that the cartilage cells are destroyed by the approach of the marrow vessels and their osteoblasts; Park, however, believes that the osteoblasts arise in part from cartilage cells which have undergone metaplasia. It is claimed by some that the calcified cartilaginous matrix is eroded at the approach of the marrow vessels, and that the osteoblasts then produce an uncalcified bone matrix (osteoid tissue) which immediately calcifies, forming true bone. Osteoid tissue cannot, however, be demonstrated in the normal subject; the provisional and the permanent calcification seem to be continuous.

Ossification in connective tissue appears less complicated. The connective tissue swells, and a matrix develops between the cells which promptly calcifies. The connective tissue cells become transformed into osteoblasts.

In the normal individual, bone destruction proceeds simultaneously with bone



growth. The skull grows by deposition of new bone on its outer surface and erosion of its inner surface. In the long bones, both cortex and trabeculae are being continually remodeled in response to stress and strain. At a surface where bone is being destroyed there are found multinucleated giant cells (osteoclasts). These were formerly believed to be phagocytic, but it now seems probable that they result from the fusion of osteoblasts which have been left behind after the dissolution of bony matrix.

The cartilage-shaft junction (the metaphysis) in rickets presents a most confusing appearance and has been aptly termed by Park "a veritable no-man's land." The zone of maturing, deep-staining cartilage cells is deeper than normal; the cells do not arrange themselves as regularly in parallel columns. Calcification of the intercellular cartilaginous matrix occurs most irregularly if at all. The invading marrow vessels, no longer guided and confined by the rigid barriers of calcified matrix, invade the cartilage in a most disorderly fashion, and branch profusely. The zone of transition between cartilage and bone is no longer a straight, even line, but instead the irregular invasion of the marrow vessels leaves behind it tongues of cartilage surrounded by osteogenic tissue. These tongues do not dip down vertically, but often turn at bizarre angles, hence in a plane section they appear as islands of cartilage. Park has pointed out that the sudden transition from the mature cartilage cell to the osteoblast does not occur. In these isolated tongues of cartilage the cells at the center resemble normal mature cartilage, but those at the periphery of the tongue have begun to lose their deep-staining power and to resemble osteoblasts. All types of transitional forms may be found. Failure of calcification is not confined to the cartilage matrix; the bone matrix formed by the osteoblasts also calcifies poorly if at all. It is this uncalcified bone, or osteoid tissue, that forms the most characteristic feature of rickets. Without it the pathological diagnosis of rickets cannot be made. Osteoid tissue is not confined to the metaphysis; it may be found in the shaft as well. It occurs also in regions where ossification in membrane is taking place.

The rachitic metaphysis, owing to its lack of mineral support, is greatly weakened. As a result of body weight or muscular action it becomes deformed. Pressure causes it to expand laterally, and, being inelastic, it does not return to its former position. Nature attempts to compensate for this weakness by the production of new bone from periosteum, but most of this is osteoid tissue and hence of little supporting value.

In the shaft of the long bones osteoid may be seen covering the trabeculae wholly or in part. Some cases are characterized by destruction of trabeculae and cortex (atrophic rickets) but in most instances the weakening of the bones results in compensatory thickening of the cortex and perhaps the trabeculae (hypertrophic rickets). This new tissue is mostly osteoid, but scattered through it here and there are areas of calcification. In the cortex this thickening may become extreme as layer after layer of new osteoid tissue is laid down. When there are pathological fractures, it is the hypertrophic cases which respond with an abundant formation of callus; in the less common atrophic cases little or no callus may be produced.

In the flat bones, the changes are similar to those in the periosteum of the long



bones. The weakness produced by lack of mineral support is compensated for by the production of new tissue, which is, as a rule, poorly calcified.

When healing occurs, the normal conditions tend to be restored with surprising rapidity. At the epiphysis the first step is the deposition of a dense layer of lime salts in the cartilage, forming a new epiphyseal line. This is usually straight, no matter how irregular the picture may have been. Calcification of the remaining matrix and the osteoid tissue of the metaphysis follows quickly after the formation of the new epiphyseal line, closing the uncalcified gap between the new line and the shaft beneath. The osteoid tissue beneath the periosteum and that covering the trabeculae of the shaft also calcifies rapidly, but the remodeling of the metaphysis often requires months before it is complete. The correction of deformities proceeds slowly; minor deformities can be eliminated by subsequent growth and remodeling of the bone, but more severe ones may persist throughout life.

Healing is not always a continuous process. Relapses of the disease occur. Abortive attempts at healing may result in the production of transverse lines of calcification in the rachitic zone, which are conspicuous in x-ray pictures.

**Chemical Changes and Pathogenesis.**—The failure of calcification of the bones in rickets was formerly attributed to some inherent defect in the bone itself, since it could not be remedied by an abundance of calcium and phosphorus in the diet. The work of Howland and his associates indicated, however, that impaired calcification was due to an inadequate supply of bone-forming minerals in the tissue fluids. They found that in all cases of active rickets either the calcium or the inorganic phosphorus of the blood serum, or both, were diminished. In uncomplicated rickets only the inorganic phosphorus is reduced; instead of the normal figure of 4 to 6 milligrams per 100 c.c. it may be found as low as 2 or even lower. The calcium is usually unaffected except in cases complicated by tetany; it is then reduced from the normal value of 10 milligrams per 100 c.c. to 7 or lower. When effective therapy is instituted the concentrations of these elements rise to the normal value, and calcification takes place. It has been demonstrated by Shipley that rachitic bone will calcify readily *in vitro* when immersed in a medium of suitable inorganic composition. Howland and Kramer laid down an empirical rule that when the product of the calcium and inorganic phosphorus of the blood serum (in milligrams per 100 c.c.) is below 30, active rickets is present; when this product is above 40, rickets is either healing or absent. This rule has proved useful clinically although the relation is not an exact one. Whether or not rickets will develop with any given composition of the blood serum depends in large measure upon the rate of growth. Calcium and phosphorus may be present in sufficient concentration for the needs of a slowly growing bone and yet be inadequate for a more rapidly growing one. The levels of calcium and phosphorus in the serum of most normal adults would lead to rickets, if present in a rapidly growing infant. The figures of Howland and Kramer are therefore applicable only in early life.

The lowered concentration of bone-forming minerals in the blood seems to be due to an inability of the blood to hold the normal quantity. Absorption from the intestine is interfered with. Metabolism experiments (Schabad and others) have shown that in active rickets there is a diminished retention of calcium and



phosphorus or none at all.<sup>1</sup> After antirachitic therapy the retention of both elements is ample. When phosphate is administered (Heymann) it fails to raise the level of the blood phosphorus as in the normal individual; the excess phosphorus appears to escape more readily in the urine.

A lack of antirachitic factor appears to do more than reduce the holding power of the blood for calcium and phosphorus. The levels at which these elements are maintained in the blood serum seem to be far less stable, and are more readily influenced by changes in the mineral balance of the diet. In a normal individual it is possible, by the administration of calcium, to raise the blood calcium and lower the blood phosphate, and, conversely, by phosphate administration to raise the blood phosphate and lower the calcium. Large quantities must be given, however, in order to bring about these changes. In rickets, a small quantity of calcium will cause an elevation of the blood calcium and diminution of the phosphate, and a small quantity of phosphate given by mouth may depress the blood calcium sufficiently to bring on tetany. The rachitic child thus becomes a prey to minor variations in the mineral balance of his diet. It is possible that such minor variations in the diet, or perhaps in the reaction of the intestinal contents, will explain why in some instances of rickets only the phosphorus of the serum is reduced, while in others the calcium is diminished and tetany develops.

The mechanism by which the antirachitic vitamin—whether introduced by mouth or produced by irradiation of the skin—affects the holding power and the stabilizing power of the blood is as yet completely obscure. Another obscure feature is the relation of the parathyroid hormone to rickets. In its action the parathyroid hormone presents many points of similarity to irradiated ergosterol. Both of these factors exert a stabilizing effect on the level of calcium and phosphorus in the blood serum. In excessive doses both may cause decalcification of the bones and pathological calcification in the soft tissues. Ergosterol, however, increases the holding power of the blood for both calcium and phosphorus, whereas the parathyroid hormone causes, ordinarily, only the calcium to rise; the phosphorus falls at first but in toxic doses a late rise to abnormally high levels may be observed. Hypertrophy of the parathyroid glands occurs in rickets, and it has been suggested that this is a compensatory phenomenon. Failure of such compensatory hypertrophy may be in part responsible for the cases that develop tetany.

**Symptoms.**—The symptoms by which rickets is recognized relate to the bones. Sweating about the head, fretfulness, constipation and other indefinite symptoms were formerly regarded as characteristic, but it is doubtful if any of these bears a definite relation to rickets.

The bone manifestations vary with the age of the infant, some bones being more vulnerable at one time than another. These differences are due partly to variations in the growth and development of the bones, and partly to the varying activities of different age periods; a child who sits or stands is subjected to stresses quite different from those in a recumbent infant. During the first eight months of life the skull bears the brunt of the attack. It grows with great rapidity at this time. Because of its peculiar method of growth—it is continuously destroyed

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<sup>1</sup> This holds true when both elements are fed in normal ratios. When one is given in excess it may be retained in normal amounts, but there is a corresponding loss of the other element.



from within and rebuilt from without—the increase in circumference gives little idea of the quantity of new bone produced. At this time of life the stress caused by the recumbent posture is almost constantly applied. The young rachitic infant develops soft spots in the skull (craniotabes); they are usually the first, sometimes the only manifestation of the disease. Bossing of the head develops as a rule during the latter half of the first year, but may remain in evidence long after this. Changes at the cartilage-shaft junctions of the long bones begin to appear at about six months of age; they continue as long as ossification in these regions is



FIG. 30.—MARKED RICKETS SHOWING CURVATURE OF SPINE, ENLARGED COSTOCHONDRAL JUNCTIONS (BEADED RIBS) AND POT-BELLY.

proceeding rapidly—in the ribs up to about the eighteenth month, in the long bones of the extremities up to the fourth year. The shafts are affected in all severe cases; rarefaction permits bending and pathological fractures to occur. These may develop during the first year. In late rickets almost the only objective evidences of the disease are the deformities resulting from bending.

A child who develops rickets at three or four months of age is likely to exhibit little more than craniotabes. A moderately severe case, seen at six or eight months of age, presents a striking picture (Fig. 30) with an enlarged, square head, beaded ribs, narrow, flaring chest, prominent abdomen and symmetrical swellings of the epiphyses of the wrists and ankles. If the disease continues unchecked, by



the end of the first year craniotabes can no longer be found but the other changes have become more pronounced. In the severest cases nearly every bone in the body is affected. The thorax may be greatly deformed. As a result of the sitting posture deformities of the spine and pelvis have developed. The "cross-legged" deformity of the legs may be seen. Bowing of the arms results from supporting the weight of the trunk. If active rickets persists into the age of walking the legs suffer more than the arms; knock knees, bow legs and coxa vara originate at this time. Kyphosis of the lumbar spine is replaced by an exaggerated lordosis.

The onset of rickets is always insidious. On this account the disease is often neglected for weeks and months until its manifestations have become very striking. In recent years, with the increase in popular knowledge about rickets and the widespread use of prophylactic measures, severe rickets is becoming infrequent. Most cases are brought to the physician in the early stages, with craniotabes and beading of the ribs, or perhaps with mild deformities of the chest and thorax. The various manifestations of rickets will now be considered in detail.

*Changes in the Head.*—Craniotabes may be defined as a softening in the skull which permits it to be indented with the finger. Rachitic craniotabes occurs characteristically in the occipital or parietal bones in the vicinity of or perhaps adjoining the lambdoidal suture. The softening occurs in localized areas, 2 to 4 centimeters in diameter, one or more of which may be present; often a definite crackling sensation is produced when these are indented.

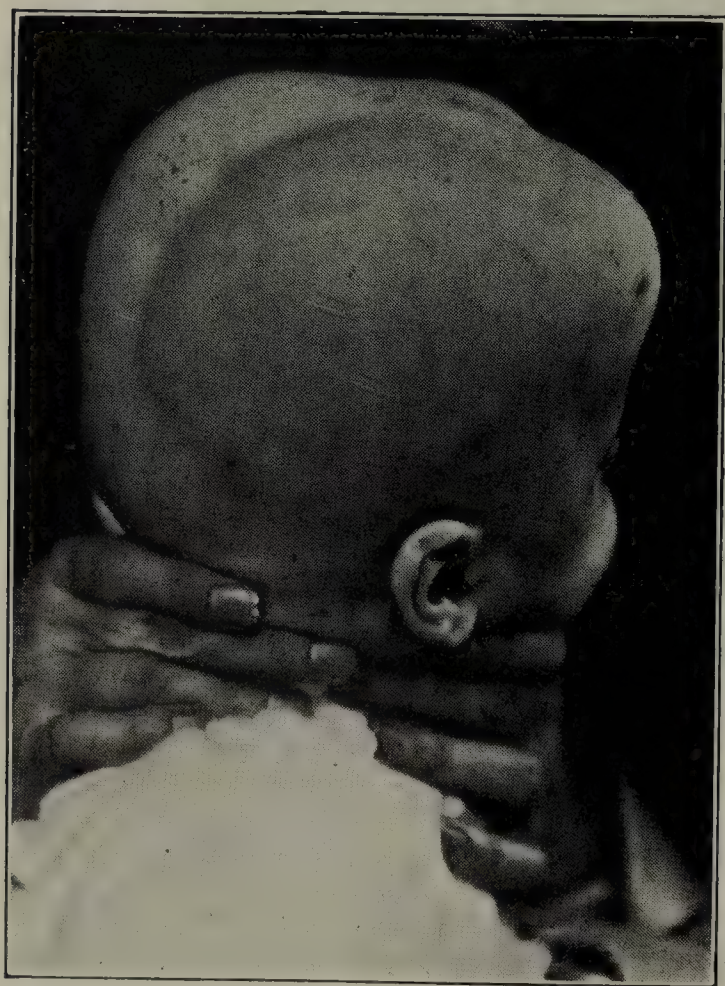


FIG. 31.—RACHITIC HEAD.

A somewhat similar softening of the skull may be found with extreme hydrocephalus; in osteogenesis imperfecta the skull may be entirely membranous. These, however, are rare events; softening of the skull almost always means rickets. In early infancy a mild degree of flexibility along the suture lines is commonly found which is spoken of as "physiological craniotabes"; this is particularly striking in young premature infants. This condition bears no relation to rickets; it is found along all of the sutures almost equally and does not tend to be localized. There is no crackling sensation on pressure. Sometimes, notably in the premature infant, wide areas of softening adjacent to the sutures persist for several months, a state of affairs for which rickets is usually responsible. It may then be difficult to decide whether craniotabes is ra-

chitic or physiological. The most important criteria are the age of the patient, the localization and irregularity of the lesion; sometimes only the response to therapy will decide. Syphilis does not, as was once believed, cause craniotabes; but since it is a common cause of prematurity it thus predisposes to rickets and to rachitic craniotabes.



The head shows very definite changes in rickets, both in size and shape. In mild cases the circumference is not increased but the head often appears out of proportion to the rest of the body. In marked cases the increase in circumference may be two or three inches. The enlargement is chiefly due to thickening of the cranial bones. In one case with marked deformity, we found the skull over the parietal bones an inch in thickness. This thickening diminishes with recovery, but in many cases the head remains throughout life larger than it should be.

The shape of the typical rachitic head is somewhat square (*caput quadratum*) owing to the formation of large bosses over the parietal and frontal eminences. It may be flattened at the occiput from pressure, and flattened also at the vertex. In extreme cases, the prominences upon the frontal and parietal bones may be so great as to produce quite a marked furrow along the line of the sagittal and frontal

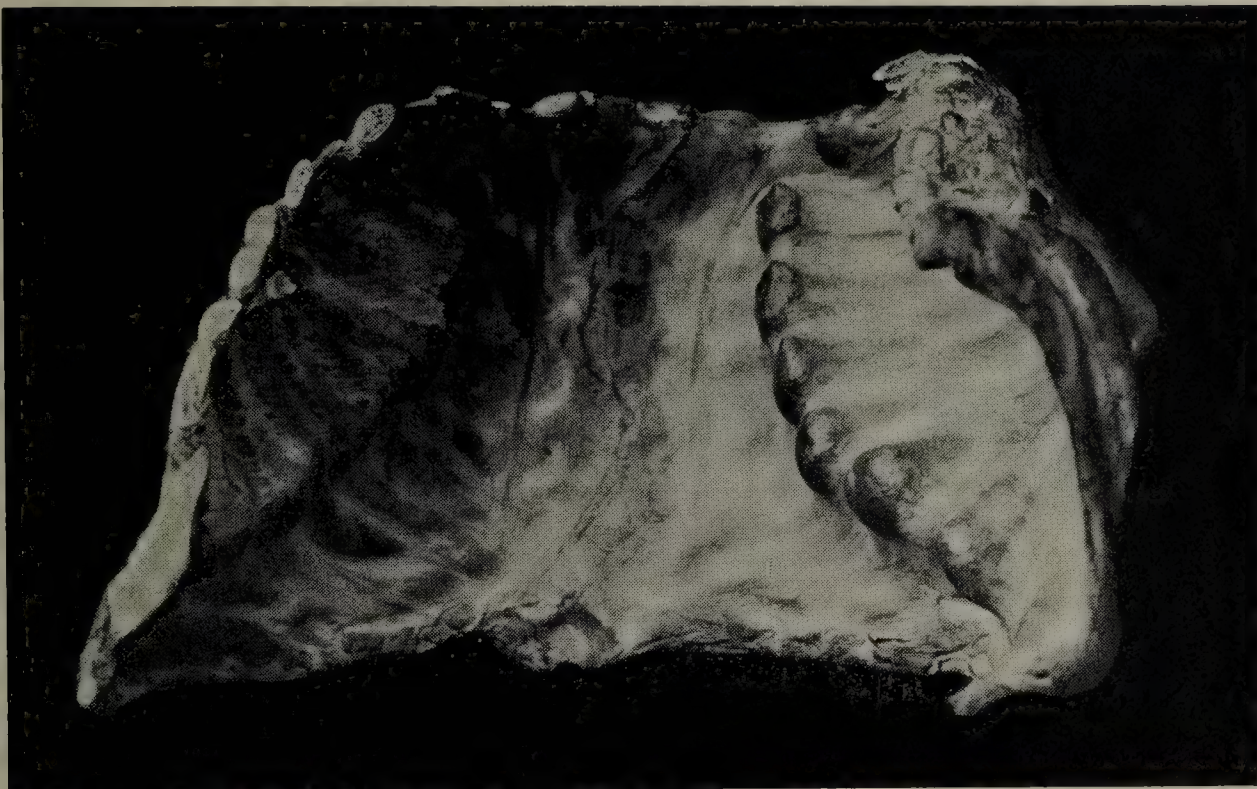


FIG. 32.—DEFORMITY OF THE CHEST IN SEVERE RICKETS: INTERNAL VIEW.

sutures, and one at right angles to this along the coronal suture. This condition gives unusual prominence to the forehead (*Olympian brow*). Mobility of the bones of the cranial vault at the sutures may exist for an abnormal length of time, occasionally until the end of the first year. The fontanel is late in closing, being frequently found open at two and a half and sometimes even at three years. Often at eighteen or twenty months the fontanel is two inches in diameter. The veins of the scalp are often prominent, and the hair is frequently worn from the occiput, owing to restlessness during sleep. Occasionally rickets and hydrocephalus are associated, but the association is accidental.

*Chest.*—Beading of the ribs is one of the most constant symptoms of the disease, and is usually the earliest manifestation to attract attention. This forms the so-called “rachitic rosary,” consisting of nodules at the line of junction of the ribs and costal cartilages. The middle ribs are chiefly affected. The costochondral junctions of normal infants, particularly during the early months, are readily palpable, and it requires experience to distinguish from this the degree of enlargement seen in mild rickets. Scurvy may cause beading of the ribs that is indistinguishable from rickets, but does not cause the thoracic deformities so



characteristic of rickets. In marked cases the enlargements at the costochondral junctions may attain the size of small marbles. In many cases with marked thoracic deformity little or no beading of the ribs is seen externally, although at autopsy it is found to be very marked upon the internal surface of the chest (Fig. 32). The resulting lateral furrows in the chest wall cause a great diminution in its transverse diameter, while the anteroposterior diameter is increased (see Fig. 33 A and B).

Another frequent deformity is the so-called "rachitic girdle" (Harrison's groove), which consists in a transverse depression about two inches broad involving both sides of the chest, a short distance above its lower border. The chest wall yields at the attachment of the diaphragm, which becomes more nearly horizontal.

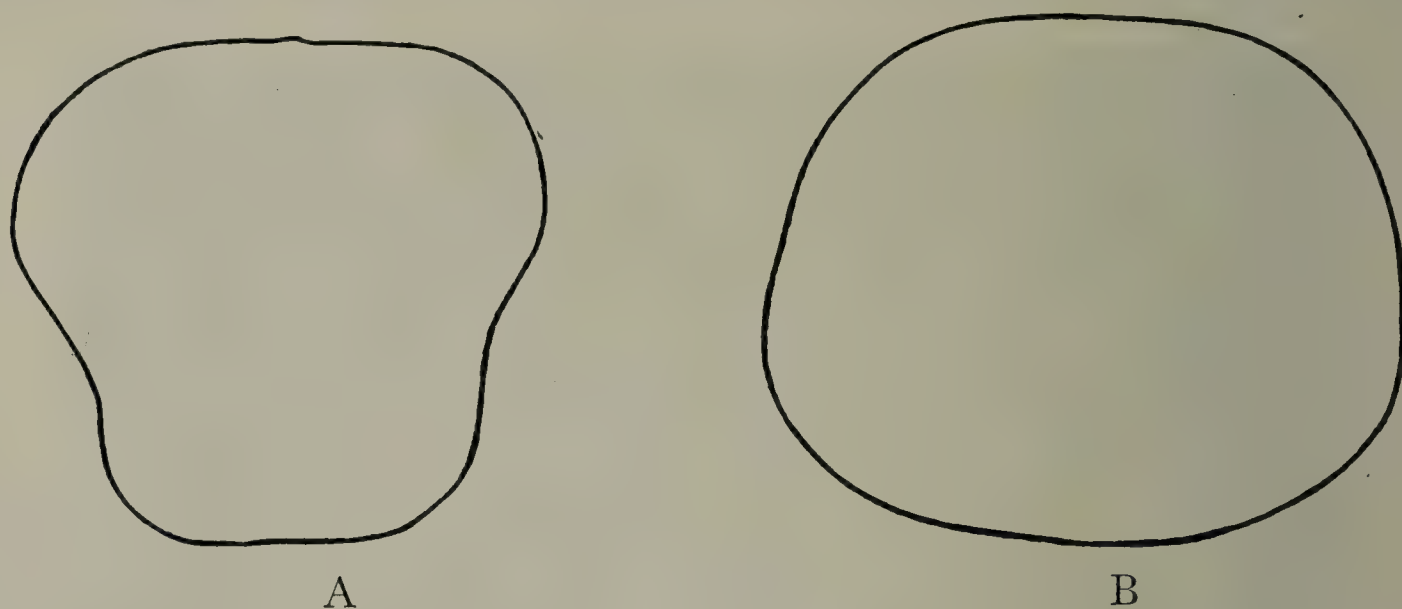


FIG. 33.—A, HORIZONTAL SECTION OF A RACHITIC CHEST IN CHILD TWO YEARS OLD, SHOWING LATERAL FURROWS.

B, SECTION OF CHEST OF HEALTHY CHILD OF THE SAME AGE.

As a result of this the liver and spleen become displaced downward. Eversion of the lower border of the ribs is often associated with the above deformity. It appears to be due in part to the inward pull of the diaphragm and in part to abdominal distention.

The factors in the production of thoracic deformities are the contraction of the diaphragm and atmospheric pressure acting upon the soft chest walls, which in the latter instance yield at the point of least resistance—the junction of the costal cartilages and ribs. Because of the support given by the heart, Harrison's groove is usually less extensive on the left side than on the right. Pigeon-breast is occasionally seen, but it is doubtful if this depends on rickets alone. Funnel chest has been ascribed to rickets, but it seems more likely that this represents some congenital anomaly.

Deformities may have far-reaching consequences. The capacity of the thorax to expand is limited, and this may play a part in the increased susceptibility to respiratory infection which these children exhibit. When there exists obstruction to the entrance of air, as with bronchitis, hypertrophied tonsils or adenoids, the deformities are likely to be much exaggerated. Cases with extreme thoracic deformity have been graphically described by Howland and Park. Not only does the thorax fail to expand in inspiration, but owing to the collapse of its weakened



walls the circumference may actually diminish. Life is maintained by the action of the diaphragm, which, however, works at a great disadvantage, since much of its work is expended in compressing the thorax. Respiration is shallow, very rapid and grunting, simulating an acute respiratory infection. Deformity of the thorax does not occur if rickets develops after the first year, for the bones have by then become rigid, and their growth is comparatively slow.

*Spine.*—This is seldom involved in the milder cases. The deformity is brought about by weakness of the muscles and probably also by relaxation of the ligaments. The usual type seen is a posterior curve (kyphosis), which is a general one extending from the mid-dorsal to the sacral region (Fig. 30). This is found in nearly half of the severe cases. Early in the disease it disappears on suspending the child, but not so in cases of long standing. Lateral curvatures are less frequently seen. Deformity of the spine in a child under three years is nearly always rachitic.

*Clavicle.*—This is deformed only in severe cases. The usual deformity consists in an exaggeration of the anterior curve at the inner third of the bone, which is somewhat shortened and its extremities enlarged. It is not infrequently the seat of greenstick fracture.

*Pelvis.*—Deformities here are frequent. The most common rachitic changes are a diminution of the anteroposterior diameter and a narrowing of the pubic arch. Rachitic deformities of the pelvis rank among the commonest causes of dystocia, particularly in the colored race.

*Extremities.*—The most common changes are enlargements of the epiphyses of the wrists and ankles, which give the joints a “double” appearance. Even in mild cases in which this change cannot be found clinically, rachitic changes here can be detected by the x-ray. Changes at the upper end of the femur and of the humerus are not infrequent, but can seldom be recognized clinically. The epiphyses at the elbow and knee are involved only in the more severe cases. Enlargements of the ends of the metacarpal bones we have seen but seldom. Rarely there may be thickening of the cortex of the proximal phalanges, giving rise to the so-called “beading of the fingers.” Deformities at the epiphyses may result from displacement or from tilting of the epiphysis with respect to the shaft. Bow legs and knock knees are due to tilting of the epiphyses of the condyles of the femur. The enlarged epiphyses of rickets are rarely confused with any other condition. During the first weeks of life, swollen epiphyses may be found in severe cases of congenital lues; these are likely to be painful, unlike the changes in rickets. Scurvy may cause swollen, tender epiphyses. The tenderness and the x-ray picture will serve to differentiate this from rickets, as well as other manifestations of the disease.

Bending occurs in almost all of the long bones. Changes in the upper extremities are seen most frequently in creeping children. The radius and ulna present a convexity on their extensor surfaces which may be marked. The humerus may have an outward and a forward curve, although it rarely exhibits a marked deformity. In the lower extremities the deformities depend in large part upon the child's ability to walk. In walking children bow legs may result from softening of the tibia and fibula, and coxa vara from curvature of the neck of the femur. Deformities of the femur are less common than those of the tibia and fibula. Other



deformities occur in children who are unable to walk. There may be a general forward and outward curve of the femur which is mainly due to the weight of the legs as the child sits. In children who have been allowed to sit much in a cross-legged posture, very characteristic deformities develop. The femur is usually rotated outward, with the result that when such children later walk the toes are turned very far outward. When the feet have been persistently crossed there develops a sharp anterior bowing a short distance above the ankles due to the weight of the feet. The same deformity may result from the child's sitting in an adult chair, over the end of which his feet project.

Fractures of the long bones are quite frequent in the more severe cases of rickets. They are usually multiple and of the greenstick variety. They occur from very slight causes, probably from traumatism so mild as to escape attention. Often the fracture is subperiosteal. Any of the long bones may be involved—the most frequent being the fibula, the radius and ulna, the femur and the ribs. Often these fractures are not suspected until an x-ray is taken.

Early walking has been blamed for many of the deformities of rickets, but we are not impressed with its importance as an etiological factor. Owing to the weakness of their muscles infants with rickets are usually late in beginning to walk.

Although the extent to which repair of these deformities takes place when the process heals is often astonishing, a certain amount of stunting of growth may remain; this is the rule when severe rickets has been present.

*Ligaments.*—All the ligaments, but particularly those about the large joints, are lax and frequently elongated. This may lead to the deformity known as weak ankles, or to an overextension at the knee (*genu recurvatum*); also to unnatural mobility at the hips, shoulders, elbows, or wrists. The condition of the ligaments plays an important part in the production of spinal deformities. These various deformities are, however, not necessarily rachitic in origin.

*Muscles.*—Muscular symptoms are present in almost all marked cases. The muscles are small, very flabby, and poorly developed; hence rachitic children are unable to sit erect, or to stand or walk at the usual age. Of 151 cases in which the date of walking alone was investigated, only 27, or 18 per cent, walked before the fifteenth month; 47 per cent were not walking at the eighteenth month; 20 per cent, not at two years; and 10 per cent, not at two and a half years. Late walking is a common symptom for which advice is sought by parents with rachitic children. The muscular power in the extremities is sometimes so feeble as to suggest paralysis. The muscular symptoms may be marked when the bony changes are slight, and conversely.

Two other symptoms depend chiefly upon the condition of the muscles: pot-belly and constipation. Pot-belly is quite an early symptom, and in most cases a very marked one. It was noted in 60 per cent of our cases. The enlargement of the abdomen is uniform. It is everywhere tympanitic, and it may be as tense as a drumhead. This is due to a loss of tone in the abdominal muscles, and in the muscular walls of the stomach and intestine. It is aggravated by chronic indigestion. The enlargement is thus mainly from tympanites. There may be a marked degree of dilatation both of the stomach and the colon. Constipation is not infrequent.



*Dentition.*—As a rule, dentition is late. Individual cases, however, present great variation in regard to this symptom. A study of the progress of dentition in 150 rachitic children gave the following results: in 50 per cent the first teeth were cut on or before the eighth month; 20 per cent of the cases had no teeth at twelve months, and in 8 per cent none had appeared at fifteen months. Even though the first teeth come at the usual time, the progress of dentition is usually retarded by the development of rickets. The character of the first teeth in rickets is usually good. This is in striking contrast to hereditary syphilis, where the tendency to early decay is seen. The teeth of the second set are frequently lacking in enamel and decay early.

*General Appearance.*—Rachitic patients are often pale. They are prone to suffer from hypertrophied tonsils, adenoid growths of the pharynx, and enlargements of the lymph nodes of the neck. Their resistance to infection is feeble. They are especially subject to infections of the respiratory tract; digestion is easily disturbed.

The downward displacement of the liver and spleen from contraction of the chest should not be mistaken for enlargement of these organs. Moderate enlargement of the spleen is usually associated with anemia. It does not depend on the rachitic process *per se*.

*Blood.*—Anemia is a frequent accompaniment of rickets; its intensity seems to be related to the severity of the rachitic process. The blood picture shows nothing to differentiate it from other secondary anemias.

*Tetany.*—Infantile tetany may quite properly be looked upon as a manifestation of rickets. It results apparently from the same disorder of metabolism, as has already been pointed out.

**Special Forms of Rickets.**—*Congenital Rickets.*—This has already been referred to. It is seen only in children born of mothers suffering from osteomalacia.

*Late Rickets.*—Instances of rickets occur from time to time in children from six to fifteen years of age. Following the World War a considerable number of such cases were observed in countries where the food supply was insufficient.

The children become anemic and weak. Often they have difficulty in going upstairs. Pain is said to be a marked feature. It occurs in the joints, especially in the knees, and in the back. There is great fatigability and muscular weakness. The changes in the bones are most marked in the extremities, particularly the lower extremities. The epiphyses are more or less enlarged and deformities such as bow legs and knock knees occur. With the x-ray it is made out that the density of the bones is diminished and the cartilaginous zone between the epiphysis and diaphysis is widened. There may even be cupping of the end of the diaphysis. The deformity is rarely severe.

In this country late rickets is rare except in association with celiac disease and chronic renal insufficiency.

*Celiac Rickets.*—Bone changes are not infrequently found in cases of celiac disease (chronic intestinal indigestion). In some instances only osteoporosis is present; in others there is true rickets. The picture of rickets depends upon the age of the child; in older children it is that of "late rickets." The chemical changes in the blood are those of infantile rickets; either the calcium or the inorganic



phosphorus of the serum or both may be diminished; low calcium types are not infrequent and the picture may then be complicated by tetany. Celiac rickets shows the same diminution in calcium and phosphorus retention which characterizes infantile rickets; there is the same lability of the calcium and phosphorus level of the blood. We have every reason to believe that the cause is the same, a deficiency of vitamin D. Fat absorption is known to be defective in celiac disease and in all probability the absorption of vitamin D is likewise impaired. The condition responds to antirachitic therapy, but the response is often less rapid than in the case of infantile rickets, and intensive therapy may be required.

*Renal Rickets.*—Attention has recently been drawn to this entity by Parsons in particular. We have seen several instances. In conditions associated with a chronic renal insufficiency, most commonly with double hydronephrosis, congenital cystic kidneys or chronic interstitial nephritis, there may be found bone changes in which rickets appears to play a prominent part. Osteoporosis, softening of the bones, and some of the characteristic deformities may be found, and osteoid tissue has been demonstrated microscopically. The most striking change, however, pertains to the growth of the bones, which is greatly retarded; stunting of growth may be extreme. The onset of renal rickets is usually insidious. Either the dwarfism or the bone changes or the symptoms of renal insufficiency may direct attention to it. In any case of late rickets the renal function should always be investigated.

The pathogenesis of this condition remains obscure. There are characteristic alterations in the blood electrolytes. The picture varies from time to time, but as a rule there is an acidosis, a marked elevation of the phosphorus and a reduction of the blood calcium. This last may be sufficient to bring on tetany. Calculations have indicated that the blood is not less saturated with respect to calcium phosphate than in the normal subject; the occurrence of rickets cannot be attributed to a deficient supply of bone-forming minerals in the blood. Antirachitic therapy is quite ineffectual. It is possible that a local acidosis of the tissue fluids in contact with the bone is at the root of the difficulty.

Unless the renal function can be restored, as in the case of uremia due to a removable obstruction, little is to be expected from therapy. A high calcium low phosphorus diet is indicated to correct the abnormal ratio of these elements in the blood; something can be accomplished by means of bicarbonate. As in all conditions of impaired renal function, bicarbonate must be used with caution, for it is not excreted readily and may quickly give rise to alkalosis and tetany.

**Diagnosis.**—This may be made on clinical, radiographic or chemical grounds.

*Clinical Diagnosis.*—It may be a matter of considerable difficulty to differentiate between the normal infant and one with incipient rickets; errors are made in both directions. The most important early signs are craniotabes and beading of the ribs, but “physiological craniotabes” may well be mistaken for rachitic, and it requires experience to distinguish between the costochondral junctions of a normal child and one with rickets; even the experienced observer is occasionally deceived. Enlarged epiphyses may be a familial characteristic, and the same may be said of prominent frontal bosses, or a flat occiput. In most instances of rickets, however, the diagnosis is easily made; in the more pronounced cases, it can usually be made at a glance.



Special symptoms, when unusually prominent, may give rise to difficulties in diagnosis. The enlargement of the head may be mistaken for hydrocephalus. The delayed dentition and large fontanel of the cretin may be mistaken for rickets. Muscular weakness may be sufficiently marked to suggest amyotonia congenita. A large abdomen with flaring ribs and Harrison's groove may be due to any other cause of abdominal distention. A deformed thorax may be congenital or the result of respiratory obstruction. Osteogenesis imperfecta with multiple fractures may be mistaken for rickets. Chondrodystrophy bears only a superficial resemblance to it.

The bone changes of early syphilis and of scurvy may be confused with those of rickets. Pain and pseudoparalysis occur both in syphilis and scurvy but not in rickets. Rickets does not produce epiphyseal separations. The changes of rickets are almost invariably symmetrical, while those of syphilis and scurvy may not be. Marked swelling about the knee as compared with the ankle points to scurvy. The difficulties of diagnosis are increased by the fact that, owing to dietetic errors, rickets and scurvy are often associated.

The diagnosis of rachitic curvature of the spine from Pott's disease will be considered under the latter condition.

*Roentgenographic Diagnosis.*—The x-ray has proved exceedingly useful in the diagnosis of rickets. With its aid the disease can be recognized before clinical evidences have appeared, and it gives important information as to the activity of the process. The bones usually employed are the lower end of the radius and ulna, for in these locations the changes can most readily be appreciated. The appearance varies much according to the stage of the disease (Fig. 34).

In active rickets changes are seen both at the epiphysis and in the shaft. The earliest changes are detected at the epiphyseal line, which becomes indistinct and irregular; the shaft of the bone terminates in a fringed border. Broadening and cupping of the epiphyseal end of the shaft begin at an early stage.

In the more advanced cases there is marked cupping and fraying of the epiphyseal end of the shaft, and it is apparent that the distance between the calcified portion of the shaft and the epiphyseal center is greater than normal. The shaft shows a loss of density due to osteoporosis which affects both the cortex and the trabeculae. In many instances the shaft shows a coarse trabeculation in which the trabeculae appear to stand out with undue prominence. As Park has pointed out this is not due to the trabeculae at all but to variations in the density of the overlying cortex or cortices. When rickets has persisted for some time, compensatory hypertrophic changes are likely to occur. Layer after layer of new cortex may be laid down from the periosteum; most of this new tissue is osteoid, and only here and there are irregular calcified areas which give rise to the x-ray picture of the "trabeculated" shaft. When bending has taken place, this new cortical tissue is found to be particularly abundant on the concave surface of the shaft. Analogous changes take place in the epiphyseal center of ossification. Its outside margin becomes blurred and indistinct; its density is decreased and it may exhibit a trabeculated appearance.

When healing commences, either spontaneously or as the result of treatment, the first sign to appear is a linear shadow a little distance beyond the end of the shaft on the epiphyseal side, which results from the formation of a new epiphyseal



line of calcification. Between this and the end of the shaft is an area casting no shadow, occupied largely by osteoid tissue. As healing progresses this area gradually becomes calcified and the shadow cast by the new epiphyseal line fuses with that of the shaft. The bone thus appears to grow rapidly in length, and the end of the shaft approaches more closely the epiphyseal center of ossification. This center, too, shows typical changes. It becomes surrounded with a new shell of calcification which gradually fuses with the rest of the center, giving it a sharp border again.

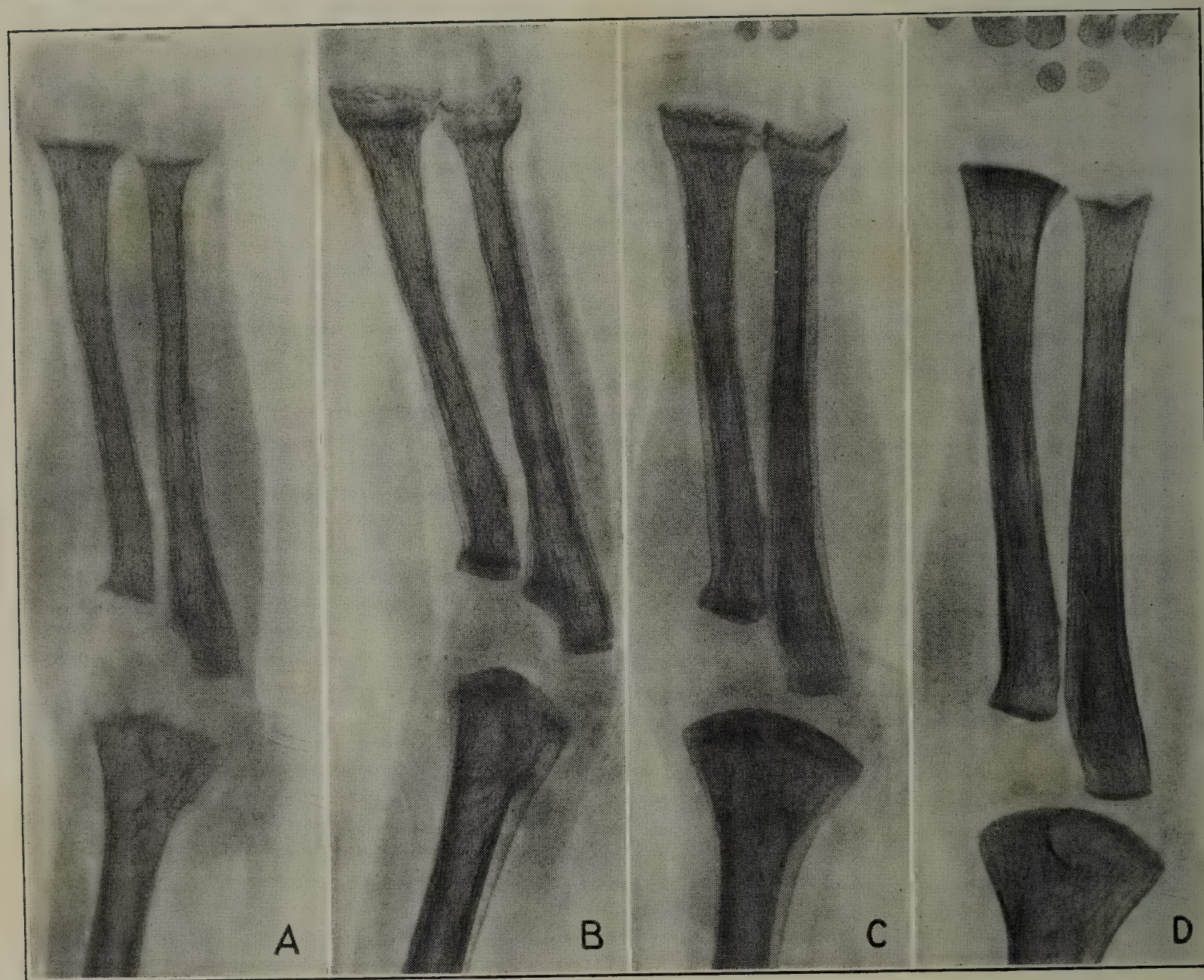


FIG. 34.—ROENTGEN-RAY APPEARANCE OF THE BONES IN RICKETS.

A. Active rickets. B. Healing in progress after twenty-seven days' treatment, showing new line of calcification in metaphyses. C. Healing after thirty-four days' treatment; dense lines of calcification; increase in periosteal calcification. D. Complete healing after three months. (Reproduced by courtesy of the Medical Research Council.)

The increase in density of the shaft takes place more gradually. When there has been marked proliferation of the cortex, this too gradually becomes calcified and casts a shadow. The eventual result is a greatly thickened, compact cortex in this region.

The x-ray picture of active rickets can scarcely be mistaken for any other condition. The osteoporosis, the frayed margin at the epiphyseal end of the shaft and epiphyseal center, and the cup-like deformity at the epiphyseal end of the shaft are quite characteristic. The picture of healing may, however, be confused with that of scurvy or early syphilis, in both of which there may occur increased



periosteal shadows and an unusually dense shadow at the epiphyseal line with a clear space beneath it. The age may be of some assistance. Scurvy is seldom seen before the fourth or fifth month, syphilitic epiphysitis seldom after that time. The periosteal shadows seen in scurvy result from subperiosteal hemorrhages and are found at one end of the shaft. Increased "trabeculation" is not seen in syphilis or scurvy. The clear area beneath the dense epiphyseal line in scurvy is usually very narrow, as compared to the width of the rachitic metaphysis. In syphilis, this zone is likely to be broad and is often most irregular, extending only part way across the end of the shaft. Cupping of the epiphysis is not found with syphilis or scurvy, and these conditions show other characteristics not present in rickets. The difficulties in differential diagnosis are greatly increased by the fact that syphilis or scurvy may coexist with rickets.

*Chemical Diagnosis.*—It has already been mentioned that the inorganic phosphorus or the calcium or both of these elements are diminished in the blood serum in rickets, and that as a rule active rickets may be assumed to exist whenever the product of these elements (expressed in milligrams per 100 c.c.) falls below 30. The diagnosis of rickets from the blood chemistry is more sensitive than either clinical or radiographic criteria; it indicates activity or healing of the disease before these can be detected by other methods.

Other chemical tests for the presence of rickets have been suggested, based upon the diminished retention of calcium and phosphorus, but it is doubtful if they supply any further information than is given by the blood serum. Metabolism experiments are not practicable as a routine procedure. The "phosphate tolerance" test, suggested by Heymann and by Warkany, in which the blood phosphorus is studied at intervals after administration of disodium phosphate, may give valuable confirmatory information. It would appear that, in active rickets, the administration of phosphate fails to increase the inorganic phosphorus of the blood, the excess phosphate being promptly excreted in the urine.

*Prognosis.*—Rickets *per se* is not a cause of death, but it is an important factor in increasing mortality in the first two years. There is reason for believing that the resistance to infections in general is lowered by rickets, but its chief influence is in predisposing toward respiratory infections, particularly bronchitis and pneumonia. This is largely brought about by thoracic deformities which interfere with the normal expansion of the lungs. The more marked the deformity, the greater is the susceptibility. The presence of tetany involves certain dangers, which are more fully discussed under that condition.

The extent to which rachitic deformities may be outgrown is often astonishing; but in severe cases the effects of the disease may persist into adult life. When there has been marked involvement of the lower extremities, the full stature is seldom attained. In extreme cases dwarfism may result. Deformities of the thorax and extremities may greatly impair the ability of the individual to do physical work. The obstetrical difficulties resulting from pelvic deformity have already been referred to.

*Treatment.*—The same measures will suffice both to prevent and to cure rickets—the administration of vitamin D in some form, or exposure to ultra-violet rays. More intensive treatment is required to cure rickets than to prevent



it. In severe cases, in premature infants and during infections, the ordinary therapeutic dosage may be ineffective, and larger doses must be given.

Cod liver oil is still the most generally used preparation of vitamin D. It is also a valuable source of vitamin A. Three teaspoonfuls a day of a potent preparation will prevent rickets and will cure most cases of mild or moderate rickets; it is impractical to give larger amounts than this. Unless some other form of antirachitic treatment is being employed cod liver oil should be used routinely as a prophylactic. It may be begun as soon as gain in weight is well established, beginning with one-third of the dose mentioned above and increasing to 3 teaspoonfuls a day in the course of two or three weeks. Infants do not object to the taste of cod liver oil. It is best given before feedings, the infant's mouth being held open by pressure on the cheeks until the oil has been swallowed. Under certain circumstances cod liver oil is not a satisfactory antirachitic agent. Occasionally indigestion is aggravated by the oil, a rare event in our experience. In premature infants the quantity of oil that can be given is considerably less than in normal infants, and their need of vitamin D is greater; hence it is necessary to employ a more powerful agent, not only for therapeutic but even for prophylactic purposes. Many severe cases of rickets and a few refractory cases of mild rickets require more vitamin D than can conveniently be given in the form of cod liver oil.

Irradiated ergosterol is of particular value when a more powerful antirachitic agent than cod liver oil is needed. There is no objection to its routine use as a prophylactic. The standard preparation in use in this country (viosterol, 250 D) should be used in doses of 10 drops a day for routine prophylaxis; 15 to 20 drops a day is a satisfactory therapeutic dose for most cases of rickets. Occasionally a severe refractory case is encountered requiring as much as 40 to 60 drops a day. Premature infants should be given at least 20 drops a day if rickets is to be prevented. Harmful results are not to be feared from the quantities mentioned above.

Egg yolk contains considerable vitamin D but the quantity is variable, and it is seldom advisable to rely on this source. Concentrated preparations made from yolk of egg have been used to some extent in Europe.

Among other methods of giving vitamin D may be mentioned antirachitic treatment of the mother or cow to increase the vitamin content of the milk, and direct irradiation of milk and other foods. The nursing mother should receive antirachitic prophylaxis for her own benefit, but it is unwise to rely on this method of protecting the child, for the results are not constant.

It is possible to irradiate milk so that it is an effective antirachitic agent. Unless such a preparation has been carefully standardized as to its exact potency, it should not be employed.

Bread made with irradiated yeast has recently been introduced in this country; its purpose is to provide vitamin D for older children rather than infants. The need for such a product may well be questioned.

Sun baths should always be given to infants when the climate will permit. Exposure must be commenced gradually; at first only a small part of the body should be exposed and the time limited to 10 or 15 minutes. Gradually the time



of exposure and the area are increased until the whole body is exposed for an hour. The value of this procedure can best be judged by tanning of the skin. If tanning fails to occur it is probable that insufficient ultraviolet radiation has been obtained, because of climatic or other interfering factors (see page 235) and hence it is best to give vitamin D by mouth as well.

Artificial actinotherapy by mercury vapor quartz lamps or uncovered carbon arcs has been widely used in the prevention and treatment of rickets. For prophylaxis the body is exposed every day at a distance of three feet for three to five minutes. For a cure, the time is gradually increased to twenty minutes a day. Care must be taken to protect the eyes with suitable glasses and not to burn the skin. There are few cases of rickets that will not respond to ultraviolet radiation.

The question often arises as to how long prophylaxis for rickets should be continued. There is seldom any indication for continuing it beyond the age of two years. By that time most infants are receiving a mixed diet with an abundance of egg, and have plenty of opportunity for outdoor play.

The response to therapy in active rickets is surprisingly uniform. Only to a limited extent is it affected by the intensity of the treatment. Elevation of the blood calcium and phosphorus is usually evident by the third day, and by the tenth or twelfth day a new line of calcification can be seen in the x-ray picture. In three or four weeks this becomes very striking and in a few months healing is usually complete with the exception of the deformities which may remain.

Failure to respond to the ordinary doses of antirachitic therapy is a rare event. This may be seen in cases of unusual severity. At times the presence of an infection seems to render the treatment less effective. In celiac disease, as has been pointed out, the response to treatment is slow and large doses may be required. With the exception of renal rickets, where treatment is ineffectual, we have never seen a case which failed to respond to a dose of 60 drops of viosterol (250 D) per day.

*Treatment of the Rachitic Deformities.*—The deformities of the chest are less amenable to treatment than are most of the others. After the third year something can be done by gymnastics to develop the chest muscles and to increase the pulmonary expansion.

The deformity of the spine (kyphosis) may usually be overcome by postural treatment. The patient should lie upon a hard bed; no pillow should be allowed under the head, but in severe cases one should be placed beneath the back, so that the head and buttocks are slightly lower than the lumbar spine.

In very many cases slight deformities of the extremities are outgrown when the general treatment can be properly carried out. If the deformity is not great and not increasing, it is safe to continue with general treatment only. Something may be done toward straightening the bones by intelligent manipulation. Walking should be discouraged until the bones are quite firm. Friction of the extremities and massage will do a good deal to increase muscular development. The habit of sitting cross-legged—a very common one in rachitic children—should be prevented, and in fact any other habitual posture, on account of the danger of increasing certain deformities.

The surgical treatment of severe rachitic deformities should be postponed



until an estimate can be formed as to the amount of spontaneous repair that will take place. It should not, as a rule, be undertaken before the fourth year. Before operating one should be certain that the rachitic process is completely arrested.

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## CHAPTER XXVI

### TETANY

Tetany is a condition characterized by hyperirritability of the nervous system to mechanical and electrical stimulation. Clinically it manifests itself by a certain characteristic prolonged spasm of the hands and feet (*carpopedal spasm* or *arthrogryposis*), by spasm of the larynx (*laryngismus stridulus*) and by general convulsions. It was formerly believed that tetany was rather infrequent and was manifested only by muscular spasm. Studies by electrical and chemical methods, however, have shown that in infancy and early childhood tetany is relatively common and often exists in a latent form giving no symptoms. The term "spasmophilia" or "spasmophilic diathesis" has been used to designate infants with active or latent tetany.

**Etiology.**—A number of different pathological conditions may lead to tetany, among which may be mentioned deficiency of the parathyroid secretion; prolonged vomiting; overventilation of the lungs; the administration of carbonates, phosphates, oxalates, citrates and certain other salts; certain drugs, notably guanidine and its derivatives. Tetany may occur in celiac disease, in tropical sprue and other maladies. These conditions are all of them rare in early life; they are discussed later. The overwhelming majority of cases of tetany in childhood are due to rickets, and it is this "rachitic tetany" or "infantile tetany" to which the following discussion is limited.

Infantile tetany occurs under the same conditions which cause rickets to develop. The accompanying table gives the age incidence in 293 cases of tetany from the Harriet Lane Home, which have recently been analyzed by Guild:

<i>Age</i>	<i>Per Cent</i>
First year .....	68
0- 3 months .....	7.5
3- 6 months .....	26
6- 9 months .....	26
9-12 months .....	8
Second year .....	20
Third year .....	7
Fourth year .....	4
Fifth year .....	0.4
Over 5 years.....	0.4

Although tetany may occur even in the newly born, it is rare during the first three months of life. Between three and nine months it is relatively common, after which the incidence gradually diminishes. Tetany is usually seen in the winter and spring months; it is more common in Negroes and dark-skinned races. It



develops particularly in artificially fed infants, usually those whose diet has been defective in the antirachitic factor.

Rickets can be demonstrated—either clinically or roentgenologically—in practically every case of infantile tetany. Only 4 of the 293 cases from the Harriet Lane Home failed to show such changes; 1 of these 4 came to autopsy, where definite rachitic changes were found. Although infantile tetany is thus regularly accompanied by rickets, the converse is not true, for only a small proportion of infants with rickets develop tetany. There is no parallelism between the severity of rickets and the development of tetany. Although rickets shows no sex predilection, tetany is somewhat more common in males; 62 per cent of the Harriet Lane Home cases were in boys.

Acute infections, especially when accompanied by fever, often precipitate an attack of tetany. This was true in 85 per cent of the Baltimore cases analyzed by Guild. It is probable that in such instances latent tetany was already present, the acute disease causing merely the development of active symptoms. Whether it is the fever or some unknown factor which causes this remains to be established.

**Pathology.**—There are no characteristic changes in tetany other than those of the associated rickets. Erdheim, Escherich and Yanase described changes in the parathyroid glands, consisting of hemorrhages and their remains. Subsequent observations showed that these changes are inconstant and are not uncommon in normal individuals.

**Chemical Changes and Pathogenesis.**—As Howland and Marriott first demonstrated, the calcium of the blood serum is regularly reduced in infantile tetany, and it is to this factor that the increased irritability of the nerves can be attributed.

As has been explained in connection with rickets, the blood loses its ability to hold calcium and inorganic phosphorus in normal quantities; one or the other or both of these elements may be reduced. Tetany appears only in those cases with a low serum calcium. When the calcium is increased by suitable therapy the tetany disappears.

Why in some instances the calcium should be reduced and in others the phosphorus, is not yet clear. It is known that in rickets the calcium and phosphorus levels in the blood serum are very labile, and are readily influenced by changes in the intake of these minerals. It is conceivable that minor variations in the Ca/P ratio of the diet which normally would be of no significance might determine whether “low calcium” or “low phosphorus” rickets would result. A change in the reaction of the intestinal contents might also be significant. A third possibility is that when the blood calcium level is menaced, the body protects itself by compensatory hypersecretion of the parathyroid hormone; only when such compensation fails does tetany develop. This last view is supported by some recent animal experiments, but cannot yet be regarded as established. Gerstenberger has maintained that inadequate antirachitic treatment tends to produce low calcium rickets.

**Symptoms.**—One of the most characteristic and striking manifestations of tetany is carpopedal spasm. The spasm of the hands and feet may develop abruptly, or it may be preceded by sensory disturbances. The upper extremities are usually first affected and both sides equally. The position is characteristic: the fingers are flexed at the metacarpophalangeal joints and the phalanges extended;



the thumbs are adducted almost to the little finger; the wrist is flexed acutely and the hand drawn somewhat to the ulnar side. If the spasm is very marked no motion is allowed at the wrist. The feet are in plantar flexion, sometimes in the position of equinovarus. The proximal row of phalanges of the toes is flexed, and the middle and distal rows extended; the plantar surface is strongly arched and the dorsum of the foot is prominent, standing out like a cushion. Motion at the elbow, shoulder, hip and knee is generally free. The spasm in many cases is limited to the hands and feet; more rarely the muscles of the thigh, usually the adductors, may be involved. In rare cases the muscles of the trunk or the face may be affected; the face assumes a characteristic drawn expression. The spasm can be voluntarily overcome to a certain extent; thus a child may open his hands to grasp objects or feed himself. As soon as active motion ceases, the hands resume their former characteristic attitude.



FIG. 35.—TETANY. CHARACTERISTIC POSITION.

Evidences of pain are frequent; it may be so severe as to cause children to cry out. Pain may be induced by an attempt to overcome the spasm, and sometimes it is constant. There is no loss of consciousness. The duration of carpopedal spasm may be from a few hours to several days. The muscular contraction is generally continuous, although there are often periods of remission. Edema of the extremities may develop if the spasm persists for a long time. Carpopedal spasm may come on spontaneously but more often it is precipitated by some febrile disturbance. It is found in no other condition and is diagnostic of tetany.

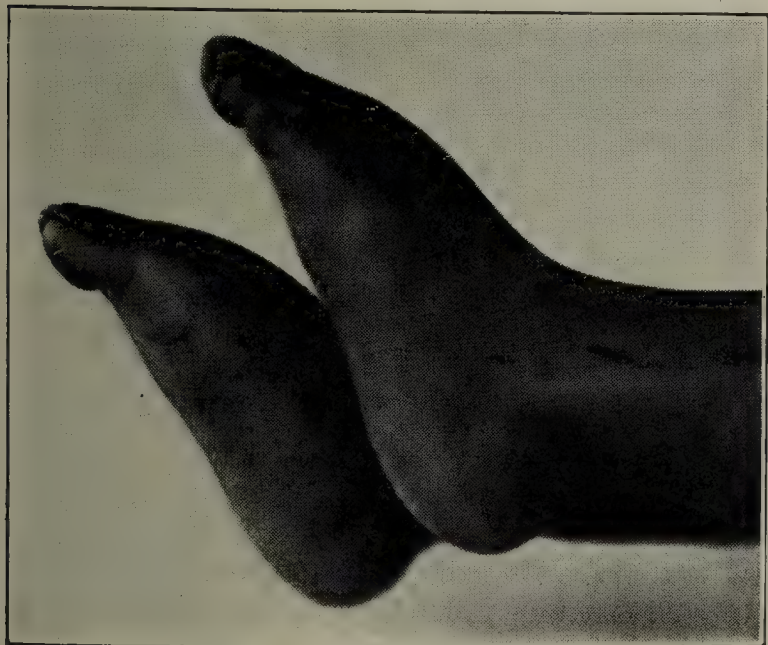


FIG. 36.—FEET IN TETANY.

Spasm of the glottis, or laryngospasm, appears frequently. This consists in a contraction of the laryngeal muscles of such intensity as partially to obstruct inspiration or for a time to arrest it. When the obstruction is partial there is a very characteristic crowing sound with each inspiration, especially if the child is disturbed or crying. The sound is identical with the "whoop" of pertussis. There may

be a succession of these sounds, followed by an intermission, or the condition may last in a mild form for several minutes or hours. The severe attacks of obstructed respiration usually come on suddenly. The child throws back his head, the face becomes pale, then livid, and for the time there is complete arrest of respiration. This continues for a few moments, during which the cyanosis



deepens, and the child seems in great distress, making violent efforts to breathe. If the paroxysm is very severe, the asphyxia may be so great as to lead to loss of consciousness, or the attack may terminate in general convulsions. It may even be fatal. In less severe attacks, after fifteen or twenty seconds the muscular spasm relaxes, the glottis opens, and a long, deep inspiration occurs, with the production of a crowing sound. Such forms of spasm often come on without evident cause, and may be repeated from two to twenty times a day. Between them the condition of the child may be normal, or carpopedal spasm and other evidences of tetany may be present. Not all the paroxysms are equally severe. A child may have in the course of a day a great many mild attacks, but only a few severe ones. Laryngospasm is most common in children from six to fifteen months of age.

General convulsions are exceedingly common with tetany in infancy. They differ in no respect from those due to other causes. They are nearly always bilateral, but in three unquestionable cases from the Harriet Lane Home unilateral convulsions were present. They may occur without any exciting cause, or the least stimulus may be sufficient to cause an attack. Thus we have seen a child who repeatedly had convulsions whenever cold was applied to the skin. The number of attacks may be very great. We have a record of one patient, observed before the days of specific treatment, who had during the latter part of his second year over 3500 distinct attacks of convulsions. For a considerable period they reached the almost incredible number of 80 a day. Death is infrequent during a convulsion but occasionally occurs.

The frequency with which the three chief manifestations of tetany are met with varies with the age of the patient (see Table XXX). Convulsions are more

TABLE XXX  
FREQUENCY OF TETANIC MANIFESTATIONS IN DIFFERENT AGE GROUPS

Age	Convulsions, Per Cent	Laryngospasm, Per Cent	Carpopedal Spasm, Per Cent
0-1 year .....	77	30	18
1-2 years .....	53	32	31
Over 2 years.....	46	4	50

common in the younger infants, and are seldom met with in older children. Laryngospasm occurs almost exclusively in the first two years of life. Carpopedal spasm is found more frequently in the tetanies of older children.

When tetany is suspected, several confirmatory signs should be sought: Chvostek's sign (the facial phenomenon), the peroneal sign, Trousseau's sign, and Erb's sign. *Chvostek's sign* consists in a momentary contraction of the muscles of the face when a branch of the facial nerve is tapped with a percussion hammer or with the finger. The nerve may be tapped anywhere, but usually best about the middle of the cheek. The contraction may affect only the mouth and the alae nasi, or it may involve any of the muscles supplied by the nerve. If the tap is made about 2 centimeters to the outside of the external canthus of the eye the contraction is usually of the eyelid only. Chvostek's sign is found in the great majority of cases of tetany; during the first two years of life it is rarely encoun-



tered in any other condition. It is sometimes found in normal infants during the first week of life; after the second year it is of more frequent occurrence and after the fifth year little reliance can be placed upon it as evidence of tetany. Wernstedt and others have maintained that a response from the upper branch of the nerve is of more significance as regards tetany, the responses obtained in the normal newly born infant and in older children being usually confined to the lower branch.

The *peroneal sign* is obtained by tapping the peroneal nerve on the lateral surface of the fibula just below the head; a dorsal flexion and abduction of the foot results. This sign has the same significance as the Chvostek; unlike the latter it can be obtained in a crying infant.

*Trousseau's sign* is elicited by pressure upon the blood vessels of an extremity with sufficient force to stop the circulation temporarily. The pressure is most conveniently applied by means of a bandage or a blood-pressure cuff. The sign is most easily obtained in the upper extremity when pressure is made above the elbow. The radial pulse should be obliterated for two or three minutes. Then the hand may assume the typical position of carpopedal spasm. The sign is often absent in well-marked tetany, but when present is to be regarded as positive evidence of the disease.

*Erb's sign* is the quantitative reaction of the nerves to the galvanic current.<sup>1</sup>

<sup>1</sup> For the electrical determinations a galvanic battery with a milliammeter graduated in fifths up to five milliamperes is necessary. The measurements are usually made upon the peroneal nerve. The large indifferent electrode, well moistened with salt solution, should be placed upon the abdomen, the stimulating electrode over the peroneal nerve in the outer part of the popliteal space near the head of the fibula. The technic of applying the stimulating electrode is important. Its position should be shifted slightly until the cathodal closing response is obtained with a minimal current. It is a wise precaution to check the values by measurements on more than one nerve. Other nerves which can be conveniently tested are the median nerve in the anterior cubital fossa and the orbital branch of the facial nerve. If lower readings are obtained in these regions it is probable that in the original instance, the stimulating electrode was improperly applied to the peroneal nerve.

The cathodal closure contraction (C.C.C.) is often obtained with a current of less than 5 milliamperes in strength in normal children under six months of age, and after this time it is regularly present with a current of this strength or a weaker one. No evidence in regard to tetany may be obtained from the C.C.C.

The anodal closure contraction (A.C.C.) usually requires more than 5 ma. of current with infants less than six months of age. From that time up to two years the A.C.C. is frequently, and after two years regularly, obtained with a current of less than 5 milliampere strength. An A.C.C., therefore, with a current of less than 5 milliamperes is suggestive of tetany only in the first six months.

The anodal opening contraction (A.O.C.) in the first six months of life occurs with normal children only with a current of more than 5 milliampere strength and up to two years it almost always requires a current of more than this. It also usually requires more current to produce an A.O.C. than an A.C.C. until the second or third year. After five years of age the A.O.C. is regularly obtained with a current of less than 5 milliamperes and less than is required to produce an A.C.C. An A.C.C., therefore, in the first six months of age obtained with a current less than 5 milliamperes is strong evidence of tetany and under two years of age is suggestive of tetany, especially if the A.O.C. takes place with a current less than is required to produce an A.C.C. This was called by Pirquet "anodal hyperexcitability." We cannot regard it as more than suggestive of tetany after six months of age, for it sometimes occurs with children who are apparently entirely normal. After two years of age it is often present and after five years of age regularly so with normal children.

A cathodal opening contraction (C.O.C.) or cathodal closing tetanus (C.C.T.) occurring with a current of less than 5 milliamperes in children under five years of age is positive evidence of tetany. After that time such values may occasionally be found with normal children.

The following table gives typical electrical thresholds in a normal subject at different ages:

Age	C.C.C.	A.C.C.	A.O.C.	C.O.C. (or C.C.T.)
3 months old .....	3.5 ma.	7.0 ma.	9.0 ma.	10.0 ma.
1 year old .....	2.5	5.0	6.0	8.0
5 years old.....	1.8	4.0	3.5	6.5

It is apparent that reactions which are entirely normal in a child of five years would, in a year-old infant, be suggestive of tetany, and in a three-months-old infant would be conclusive evidence of tetany.



Muscular contractions are produced by the application of the galvanic current to the nerves. These contractions occur with the making or breaking of the current and are called "closing" and "opening" contractions, respectively. The nerves react differently to the different poles and also to the making or breaking of the current. Age also has an important influence in the character of the electrical response. The nerves of the newly born and of infants during the first year are less responsive to the current than those of children who are older. The excitability increases with age up to about five years, after which there is little if any difference between the child and the adult. Closing contractions occur in early childhood with a weaker current than do opening contractions.

In the first six months of life any contraction with a current of less than 5 milliamperes, except that of cathodal closure, points to tetany; while an opening contraction, either cathodal or anodal, with a current weaker than 5 milliamperes is positive evidence of tetany.

Under two years of age an A.O.C. with a current of less than 5 milliamperes and weaker than one which will cause an A.C.C., is presumptive but not positive evidence of tetany. C.O.C. or C.C. tetanus with a current of less than 5 milliamperes in a child under five may be considered hyperexcitability due to tetany. Repeated measurements upon the same child often give different results in the course of a few days. For this reason several electrical examinations are frequently necessary to determine or exclude tetany.

In active tetany the serum calcium is reduced from the normal value of 10 milligrams per 100 c.c. to from 5 to 7.5 milligrams and sometimes lower. This finding is so constant as to make one question the diagnosis or the chemical determination when it is absent. The inorganic phosphorus concentration may be low, as in uncomplicated rickets, or may be normal (from 4 to 6 milligrams per 100 c.c.); occasionally high phosphorus values are met with. In the untreated case the  $\text{Ca} \times \text{P}$  product is nearly always below 40, although occasionally it lies between 40 and 45. The level of blood calcium at which manifestations appear seems to bear a definite relation to the phosphorus concentration. With a subnormal value of the latter, the threshold at which active manifestations develop is a serum calcium of 7 milligrams or less; whereas if tetany is associated with a high phosphorus, active symptoms may appear when the serum calcium is 8 milligrams per 100 c.c.

Electrical measurements upon a large number of children in hospital and outpatient practice have shown that "latent" tetany is a frequent condition and that undoubtedly only a small percentage of these children show active symptoms. Latent tetany may be demonstrated by finding the characteristic electrical responses or by a moderate reduction of the serum calcium; a concentration of 7 to 8.5 milligrams per 100 c.c. is often found. Active symptoms are likely to occur when the calcium falls below 7 milligrams but the level at which these take place is somewhat variable.

Various other symptoms have been ascribed by writers to tetany. Thus, Ibrahim has emphasized spasm of the pylorus producing vomiting; of the intestines, causing pain and meteorism; of the anal sphincter leading to obstinate constipation. The occasional retention of urine in tetany has been referred to spasm of the vesical



sphincter. The fatal outcome in some cases of general convulsions or of those with laryngospasm, it is claimed, results from tetany of the cardiac musculature. The relation of all these conditions to tetany is very doubtful.

**Diagnosis.**—This may be easy or so difficult as to require prolonged observation. Carpopedal spasm can scarcely be mistaken for anything else. This and the Trousseau sign are pathognomonic of tetany, but in about half of the cases they are both absent. Laryngospasm, when present, is positive evidence of tetany. It must be distinguished from congenital stridor, from spasmodic croup and from “breath-holding spells.” Congenital stridor can usually be identified by the history, which dates practically from birth. The symptoms are almost continuous during the waking hours and show no tendency to come in attacks. In spasmodic croup evidence of laryngeal inflammation is present, even though it may be mild; there is a hoarse voice and a barking cough; the spasm persists to some extent in expiration; it has a tendency to come on at night and to persist some hours, gradually subsiding. In tetany, on the other hand, the attacks may come on at any time; often they are momentary; there is no evidence of laryngitis. Breath-holding spells are characterized by absence of a crowing sound due to inspiration through a partially closed glottis; respiration is completely arrested and no inspiratory attempts are made during the attack. The spells occur in nervous, excitable children and are usually precipitated by temper or fright.

The most difficult cases to recognize are those in which convulsions are the only symptom of tetany. Here one must bear in mind the other possible causes of convulsions—both organic and functional. The differential diagnosis of these conditions is discussed elsewhere (page 783). In order to make the diagnosis of tetany in such instances at least one confirmatory sign must be demonstrated. The Chvostek sign is practically pathognomonic between one month and five years of age. The electrical reactions in tetany are usually characteristic, but at times may be inconclusive. The most valuable confirmatory evidence is a reduction of the serum calcium.

**Other Forms of Tetany.**—The diagnosis of other forms of tetany from infantile tetany sometimes gives rise to difficulty. Occasionally more than one factor is responsible for the condition. The manifestations of tetany itself are identical, no matter what the cause, but the various types of tetany can be recognized by their clinical associations and by characteristic alterations in the electrolytes of the blood serum.

**Parathyroid Tetany.**—Tetany from parathyroid insufficiency is rare in early life. Accidental removal at operation is not likely to happen; occasional cases are reported, however, in which absence or atrophic changes in the parathyroid have been found at autopsy. In one case seen in the Harriet Lane Home the cells of the parathyroid gland contained large vacuoles. We have seen one case of what was apparently idiopathic parathyroid tetany in a boy of five years. Like infantile tetany, parathyroid tetany is characterized by a low serum calcium; the inorganic phosphorus, however, is regularly increased, a condition found only in a small proportion of cases of untreated infantile tetany. Evidences of rickets are characteristically absent. Antirachitic treatment, as ordinarily given, is unsatisfactory, but prompt benefit is usually obtained with parathyroid hormone. There is little ten-



dency to spontaneous cure, the condition usually persisting for years. Cataract is not an uncommon complication of adult cases of this type. How frequently this occurs in early life is not accurately known. The possibility has already been mentioned that the parathyroid may play a part in the pathogenesis of infantile tetany, but conclusive proof of this is not yet available.

*Gastric Tetany.*—Tetany is often observed in association with severe or prolonged vomiting. Its cause must be sought in the loss of the acid gastric secretions, which results in a condition of alkalosis. Alkalosis, *per se*, as has been shown by Holt, Striegel and Perlzweig, does not cause tetany, but indirectly it leads to tetany by causing the production of ions which can unite with calcium:



a view first advanced by Freudenberg and György. The total calcium of the serum, as determined by analysis, may not be appreciably diminished, but it is likely that the free or ionized calcium is diminished, and it is this latter quantity, which as yet cannot be measured with accuracy, which determines the irritability of the nerves. The diagnosis of gastric tetany can be made with a history of marked vomiting, a high  $\text{CO}_2$  combining capacity in the blood serum, and an essentially normal serum calcium.

*Hyperventilation Tetany (Respiratory Tetany).*—Overventilation of the lungs regularly leads to tetany. It can be produced in a few minutes in any normal individual. The explanation of this variety of tetany is to be found in the increased loss of carbonic acid through the lungs, which leads to alkalosis. The resulting chemical changes are the same as in the preceding variety of tetany. Almost the only clinical condition in which hyperventilation tetany is seen is epidemic encephalitis, where the abnormal ventilation is caused by an irritative lesion of the respiratory center. The type of breathing is easily confused with the hyperpnea of acidosis. The blood serum shows a normal or increased  $\text{CO}_2$  capacity (but a diminished  $\text{CO}_2$  content); there is hence an *uncompensated alkalosis* (Van Slyke). The total calcium is not affected, but, just as in the case of gastric tetany, it is probable that the tetany can be attributed to a reduction of ionized calcium.

*Tetany from the Administration of Salts.*—The introduction of any salt which can form an insoluble or undissociable compound with calcium will eventually lead to tetany. Experimentally this has been accomplished by carbonates, phosphates, citrates, oxalates, fluorides and other salts. Only the first two are of clinical importance. The history of the administration of one of these compounds suggests the diagnosis; the serum calcium is reduced, although not always as much as in infantile or parathyroid tetany. When renal function is impaired these salts produce tetany much more readily, since the ions introduced are not easily excreted.

*Tetany in Nephritis.*—In conditions of chronic renal insufficiency tetany is occasionally met with even when none of the above-mentioned salts have been given. It is brought about by a retention of phosphate; the inorganic phosphate of the serum rises to high levels and the serum calcium is reduced; an acidosis is often present. Tetany in nephritis can be regarded as a form of phosphate tetany.



*Certain organic compounds*, notably guanidine and its derivatives, will produce tetany in experimental animals. Findlay, Paton and Sharpe regarded infantile tetany as a condition of guanidine intoxication, but this view has not been substantiated. The pathogenesis of guanidine tetany is still disputed; it is claimed by some that this is a low calcium tetany which will respond to calcium therapy.

*Tetany in Celiac Disease.*—In celiac disease, chronic pancreatic insufficiency and other conditions associated with excessive loss of fat from the bowel, tetany is a frequent complication. It is sometimes associated with outspoken rickets, at other times only with osteoporosis. The serum calcium, and usually the inorganic phosphate as well, are reduced. This condition, like infantile tetany and rickets, depends upon a deficiency of vitamin D. Apparently the absorption of this vitamin, like that of fat, is impaired. Response to antirachitic treatment is satisfactory, although as a rule this does not occur as rapidly as in infantile rickets.

*Postoperative Tetany.*—Tetany is occasionally seen after surgical operations when there is no possibility of direct anatomical injury to the parathyroid glands. We have observed one such instance in a girl of seven years who had always been well until operated on for enlarged tonsils. The night following operation she cried out with pain and her hands and feet were found in typical carpopedal spasm. In four or five hours the spasm disappeared spontaneously and did not recur. There were no other tetanic manifestations. The cause of such attacks is obscure; it is possible that they may be due to functional changes in the parathyroid glands.

**Prognosis.**—Although the prognosis with tetany is generally favorable, the disease should not be regarded lightly as it is associated with a definite mortality. In the cases from the Harriet Lane Home studied by Guild the mortality from tetany itself was 3 per cent. Death may occur as a result of prolonged and frequent convulsions; it may occur from asphyxia caused by laryngospasm. Sudden death may occur in patients whose condition has been in no way alarming and who have had no convulsions or marked attacks of laryngospasm; postmortem examination usually gives no explanation for the catastrophe.

There are no late sequelae of tetany. Tetany does not predispose to epileptic convulsions in later life nor to mental retardation, as was once believed.

**Treatment.**—Prophylaxis should be emphasized. Children who are adequately protected against rickets (*q.v.*) do not develop infantile tetany.

The treatment of tetany may be considered under three headings: immediate symptomatic relief; calcium or indirect calcium therapy to control the symptoms; and lastly, treatment of the underlying metabolic disturbance—rickets.

If the laryngospasm is such as to cause complete arrest of respiration, artificial respiration should be attempted. There may be instances in which intubation is indicated. The measures used for the control of convulsions are discussed elsewhere. Morphine and chloral are the most valuable sedatives to employ; with continuous convulsions a general anesthetic is indicated.

The symptoms of tetany can readily be controlled by the administration of calcium by mouth. This usually requires four to six hours before it is effective; after this time sedatives can be dispensed with. Calcium is best given in the form



of chloride.<sup>2</sup> For a child of one year, if the hydrated salt is used, an initial dose of 3 grams should be given; this may be followed by 1 gram every four hours for the first twenty-four hours. This should suffice to render the tetany latent. For latent tetany a dose of 1 gram three times a day is sufficient. The salt is conveniently given in the form of a 10 per cent solution. If the anhydrous salt is used the dose should be one-half that mentioned; it should be given as a 5 per cent solution. The administration of calcium must be kept up for at least two weeks, until the patient is well under the influence of antirachitic therapy; otherwise when the calcium is stopped tetany is likely to recur.

Any mechanism which leads to acidosis will temporarily abolish the symptoms of tetany. It is an old observation that symptoms of tetany often disappeared with the occurrence of diarrhea, and purgation was once recommended for treatment. Such results are all to be attributed to the acidosis caused by the diarrhea. Hydrochloric acid and ammonium chloride<sup>3</sup> will abolish the symptoms of active tetany, but the effect is not as prolonged or as reliable as that of calcium.

Parathyroid hormone has been used successfully in infantile tetany. It will raise the blood calcium and abolish the active symptoms, but fails to cure the underlying rickets. The latter is often made worse, since in the absence of an excess of calcium by mouth the blood calcium is increased at the expense of the bones. Unless blood calcium determinations can be made at frequent intervals it should not be employed, since there is danger of hypercalcemia.

Antirachitic treatment should not be started in cases of tetany until calcium therapy has continued for at least twenty-four hours. Unless this precaution is observed, the immediate effect of antirachitic treatment may be a sudden increase in the blood phosphorus and a fall in the calcium, bringing on symptoms of tetany anew. The dosage to be employed is discussed in connection with rickets. By means of cod liver oil, viosterol, or ultraviolet radiation it is usually possible to restore the blood calcium and phosphorus to normal figures in from ten days to two weeks. After this point has been reached calcium therapy can be relaxed.

Refractory cases are occasionally met with, just as in uncomplicated rickets. The presence of infection may render the antirachitic treatment less effective so that larger doses are required. Approximately 2 per cent of the cases seen at the Harriet Lane Home were refractory to treatment.

<sup>2</sup> Calcium chloride has a double effect. It raises the blood calcium, and it also causes an acidosis which serves to increase the ionized calcium. The acid effect of calcium chloride results from the ability of the calcium, so introduced, to combine with carbonate. The removal of  $\text{CO}_3^{--}$  ions causes the following reaction to take place:



by which hydrogen ions are liberated.

When organic salts of calcium are given, no such "acid effect" is obtained, for the oxidation of the organic radical produces carbonate and the latter is not supplied by the body. Consequently the therapeutic effect when calcium acetate or lactate is used is less than with calcium chloride. If the lactate is employed the dose should be twice that mentioned for hydrated calcium chloride. Calcium gluconate may also be used in the treatment of tetany. This salt has the advantage that it may safely be used intravenously, intramuscularly, or subcutaneously; it is available in ampules of a 10 per cent solution; 10 c.c. of this may be given every four hours. There are few occasions which call for intravenous calcium therapy.

<sup>3</sup> Inorganic ammonium salts are "acidotic" in their effect, since  $\text{NH}_4^+$  combines with  $\text{CO}_3^{--}$ , and the resulting ammonium carbonate is converted to urea:



The loss of  $\text{CO}_3^{--}$  causes the following reaction to take place by which hydrogen ions are liberated:





The treatment of other forms of tetany depends on correction of the underlying etiological factor. However, calcium and "acid therapy" are symptomatically effective with the possible single exception of guanidine tetany.

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## CHAPTER XXVII

### PELLAGRA

**Etiology.**—Although it is only recently that pellagra has attracted much attention in this country, it is unlikely that it has existed here for only a few years, but rather that it has not been recognized. Its etiology is but imperfectly understood. Three theories as to its cause have been advanced. The first and the one longest held is that it is due to the eating of spoiled corn (maize); in this, toxic products are supposed to be produced by the growth of fungi or of bacteria. The second, that it is an infectious disease of the gastro-intestinal tract, with the elaboration by the invading organisms of a photosensitive substance responsible for the peculiar skin manifestations. The third, and the view now most widely accepted, is that it is a deficiency disease. The observations of Goldberger have shown that recurrences of the disease may be prevented by a reduction in the amount of carbohydrate food and by a considerable increase in the consumption of vegetable and animal products, especially fresh milk, eggs, meat and leguminous vegetables; conversely, that pellagra may be produced by giving a diet which, though abundant, may consist chiefly of carbohydrates and from which fresh animal and vegetable products have been excluded. The characteristic feature of pellagra-producing diets is thought by some to consist in a lack of certain amino-acids. Goldberger, however, brought forward good evidence that the deficiency was a specific vitamin, which he referred to as the P-P (pellagra-preventive) factor and which is now designated as vitamin G. This is closely associated with the B group of vitamins. Corn is said to be relatively poor in the G factor, but the evidence here is conflicting.

Pellagra is seen at all ages although it is comparatively rare in very young infants. After two years of age it is much more common. It is found with greatest frequency in the states of the South Atlantic Coast, although cases have been reported from almost every state in the Union and even from Canada. Pellagra is a disease preëminently of the warm months—spring, summer and autumn. As soon as cool weather comes it usually diminishes much in severity and in frequency, but cases sometimes develop even during the winter. It is found chiefly among the poor living in unsanitary surroundings, but no class is entirely exempt. While it is found in cities as well as towns, it occurs more often in country districts.

There are no characteristic anatomical lesions in pellagra. Cellular change in the brain is common. In the cord, degeneration of the lateral and posterior columns is occasionally found, but usually only in cases that have existed for many months or years. The skin shows the changes of acute or chronic inflammation.

**Symptoms.**—The symptoms in a well-marked case are easy to recognize, but in the mild form the disease may be almost impossible to detect, and it may be a long time before a definite conclusion as to the diagnosis can be reached. There



are three chief symptoms—the cutaneous lesions, the gastro-intestinal symptoms and those of the nervous system. The cutaneous or the gastro-intestinal symptoms are those first in evidence. The eruption is found chiefly on exposed surfaces, and for this reason and because it often begins with the advent of warm weather, it is frequently mistaken for sunburn. The eruption begins as an erythema, but after a variable length of time exfoliation takes place, desquamation being in some cases



FIG. 37.—PELLAGRA.

Boy, five years old; died of the disease five months later.

very marked. The skin is thickened, rough and dry, although in exceptional circumstances vesicles and bullae may be found and ulceration even may take place. The eruption (Fig. 37) is found upon the hands, neck, face and feet, although it may spread far up the arms and legs and involve even portions of the trunk as well. It is strikingly symmetrical and the lesions are sharply outlined; when they are not so it usually indicates that the eruption is receding. There is a certain amount of brownish discoloration, its intensity depending somewhat upon the complexion of the person affected. No itching is complained of, but a slight burning or tingling sensation. The nails are unaffected. The tongue is oftentimes red;



it may be coated, with clear edges, or it may be dry and glazed. The papillae are often somewhat enlarged. The tongue may be swollen. In addition to the glossitis there may be also stomatitis and gingivitis. Burning in the mouth is an occasional complaint.

The gastric symptoms are few. Vomiting is rare. Anorexia may be marked but at times there is a craving for unusual food. Diarrhea is the rule. The stools are from two or three to as many as fifteen a day. They may be watery, but at times mucus and even blood are present. Prolonged constipation is rare, but the diarrhea often alternates with periods of constipation.

The mental symptoms are not so marked in children as in adults. Depression is often present. There is frequently a change in disposition, the children becoming dull, morose and peevish. An anxious, distressed facial expression is characteristic of marked cases. The reflexes are usually exaggerated. Ankle clonus is frequently present and there may be a decided tremor upon exertion. If the intestinal symptoms are marked, there may be great loss of weight. The progress of the symptoms is not usually continuous, but there are marked remissions and exacerbations. The disease often disappears in the fall and winter to return again the following spring and this may be repeated many times. It is for this reason difficult to say when pellagra is really cured. The prognosis in children is better than that in adults. With proper therapy the majority of cases can be cured; death may occur, however, from a continuance of the diarrhea, from the development of marked malnutrition or from intercurrent infections.

**Treatment.**—This is both dietetic and hygienic. A faulty diet, in which carbohydrates, especially corn meal, have been excessive, should be replaced by one with an abundance of milk, eggs, fresh meat, peas, beans, and fruit. Since the diarrhea is a symptom of the disease itself, it must not be allowed to deter one from prescribing a mixed diet. In children beyond the nursing age, the diet should contain a variety of foods—in fact, should be the normal vitamin-rich diet of a healthy child of the same age. Pellagrous mothers should not nurse their infants unless they are themselves under active treatment for the disease. The social and economic obstacles to successful therapy may be formidable; the disease is often an accompaniment of extreme poverty and is likely to recur unless fundamental changes in the standard of living are effected. The patient should be put in the best hygienic surroundings possible. In certain parts of this country, uncinariasis and pellagra may be found together, the one apparently predisposing to the other. Adequate treatment must embrace all such secondary factors as well as the primary dietetic requirements.

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## CHAPTER XXVIII

### OTHER DEFICIENCY DISEASES

Aside from the clear-cut deficiency diseases described in the foregoing chapters there are other clinical pictures which appear to be due to defects in the diet, although such an etiology has never been proved. Often these are associated with one or another of the avitaminoses.

*Nutritional edema* is sometimes met with in infants suffering from severe malnutrition. It is most often seen when the diet has consisted largely of carbohydrates. The finding of a reduction of the plasma protein<sup>1</sup> and of a low albumin-globulin ratio has led to the view that the condition is due to a deficiency of protein or of certain amino-acids in the diet. It is quite possible that this form of edema is identical with the "war edema" and "famine edema" seen in older children and adults. The so-called "wet form" of beriberi may be identical in origin, its association with polyneuritis being purely accidental.

A less well defined syndrome is known by the Germans under the term *Mehlnährschaden*. Czerny and Keller described this condition in infants who were fed excessive amounts of cereal decoctions and proprietary foods. The infants continued to gain weight for a time, but before long this gradually ceased and loss of weight occurred. There was an increased susceptibility to infections. Spontaneous activity diminished. The muscles became weak and flabby and a marked secondary anemia sometimes developed. One of the most characteristic changes was a peculiar rigidity of the musculature of the legs and of the neck; in some instances opisthotonos was marked. This condition, it may be noted, is quite similar to the "partial vitamin B deficiency" of Hoobler mentioned above. Its exact cause, if indeed a single cause is responsible, is still an open question. There is every reason to suppose, however, that the symptoms are due to dietary deficiency, rather than to specific injury by carbohydrates, as originally suggested.

Among the other conditions which have been regarded as deficiency diseases may be mentioned celiac disease, cachectic purpura and acrodynia.

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<sup>1</sup> It has been shown that reduction of the serum proteins leads to edema, whether this is accomplished by artificial means (plasmapheresis experiments) or by loss of albumin through the kidney (nephrosis). It may be supposed that in marasmus, protein starvation may produce these same consequences. In a number of instances the development of nutritional edema has been directly related to a low level of serum proteins. Whether this holds true of all cases cannot yet be stated with assurance.



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## SECTION V

### DISEASES OF THE ALIMENTARY TRACT

#### CHAPTER XXIX

##### DISEASES OF THE STOMACH

##### MALPOSITIONS AND MALFORMATIONS

The stomach is sometimes in the thoracic cavity in cases of diaphragmatic hernia or eventration of the diaphragm. It may be found in a vertical (fetal) position, variously adherent to the colon and small intestine. Malformations are much less frequent than those of other parts of the alimentary tract. There may be atresia or stenosis at either orifice, and very rarely a constriction is found near the middle of the organ, dividing it into compartments. The symptoms of atresia at either orifice are persistent regurgitation or vomiting, and death supervenes in a few days from inanition.

##### HYPERTROPHIC STENOSIS OF THE PYLORUS

This condition, known also as *congenital stenosis of the pylorus*, or simply as *pyloric stenosis of infancy*, is not an uncommon one. It is characterized by persistent vomiting, constipation, wasting, marked visible gastric peristalsis, and usually a palpable pyloric mass. It is a serious condition, and unless recognized early and treated properly it has a high mortality. It is seen in early infancy, usually in the first two months of life but seldom in the first two weeks. Fully three-fourths of the cases occur in male infants. It has no relation to the type of feeding employed, the large proportion of recorded cases having been seen in nursing infants.

The pathogenesis of stenosis of the pylorus in early infancy is obscure, and at the present time quite diverse views are held. It is believed by some that the primary and essential condition is one of spasm; that hypertrophy when present is secondary; that in a considerable proportion of the cases there is only pylorospasm without hypertrophy. The other view and that which seems to harmonize best with the clinical symptoms and the pathological changes is that the primary condition is one of hypertrophy which is congenital; that to this, spasm is added; that in all cases both factors—hypertrophy and spasm—are present; that while the cases differ in degree they are the same in kind. Spasm certainly plays an important part in the production of symptoms; but to regard this condition as one essentially of muscular spasm seems to us erroneous.

The appearance of the pylorus at autopsy or operation is remarkably uniform. It forms a hard, whitish tumor about the size of the terminal phalanx of the little



finger, of almost cartilaginous consistency. Its lumen may be so narrow as barely to admit a fine probe, while the normal pylorus will usually admit a No. 21 sound, French scale. Frequently water cannot be forced through the stenosed pylorus, owing probably to the fact that the mucous membrane is thrown into folds. The walls of the stomach are hypertrophied, especially toward the pyloric end. The stomach is dilated; its lower border may be below the level of the umbilicus. On section the pylorus is much thickened, often elongated as well, and the lower end may project into the duodenal lumen somewhat as the uterine cervix into the vagina. By microscopical examination the thickening is seen to be chiefly of the circular muscle fibers, which are increased to two or three times the normal width of this layer. The other coats are thickened, but to a much less degree.

**Symptoms.**—These may appear in the first week of life, but the usual history is that an infant who for the first week or ten days has given no evidence of gastric disorder, and often has been nursing and gaining regularly in weight, begins without evident cause to vomit, at first occasionally, but soon habitually. The vomiting soon becomes forcible, projectile. It may be of this type almost from the outset. Changes in diet have but a temporary effect upon it, or none at all. The usual symptoms of indigestion, such as might be expected with the vomiting, are absent. The tongue is ordinarily clean, the appetite excellent, the color is usually good, and there is no fever. The bowels are constipated. The infant wastes steadily, and often loses 1 or 2 ounces a day (30 to 60 grams). There is progressive failure in nutrition, usually with subnormal body temperature, and death may occur from inanition in from four to six weeks from the beginning of marked symptoms.

**Vomiting.**—The manner of vomiting is characteristic. It is more forcible than that seen under any nonobstructive condition. An infant will often fairly shoot out the contents of the stomach, sometimes to a distance of three or four feet. Food often comes through the nose. The vomiting usually has a relation to the taking of food. It most frequently comes directly after feeding, sometimes even while the infant is still at the breast, and may be immediately preceded by signs of pain. After an attack of vomiting, nursing is sometimes resumed with avidity, showing a distinct absence of nausea or anorexia. All the food is generally expelled at one time; frequent regurgitation of small amounts is unusual. Generally vomiting does not occur at night unless the infant is nursed at that time. The vomitus usually consists only of food, often but little changed. Bile-staining of the stomach contents is extremely rare. The amount vomited at one time may be even greater than the feeding just taken, suggesting a considerable retention of food in the stomach. Some of these patients vomit regularly after every feeding; others retain two or three feedings and then expel the whole amount. The frequency of vomiting varies from once or twice to six or eight times a day. Owing to the loss of fluid by vomiting the infant may become greatly dehydrated; the skin becomes dry and inelastic and the urine is scanty. The changes in the plasma electrolytes in severe vomiting are discussed elsewhere (page 53). The loss of acid in the gastric secretions far exceeds the loss of base; an alkalosis results, which occasionally may be severe enough to lead to tetany. The usual picture is a slight lowering of plasma fixed base, a marked reduction of plasma chloride, and an elevation of bicarbonate.



*Stools.*—Obstinate constipation is the rule. It is due to the fact that so much of the food taken is vomited. If the pyloric obstruction is complete the stools resemble meconium. Occasionally even when vomiting is severe, there may be diarrheal stools, consisting mostly of mucus and other secretions.

*Wasting.*—Progressive wasting is one of the striking symptoms, and a close observation of the weight one of our best guides to the progress of the case. If the loss amounts to as much as a fourth of the maximum body weight the condition should be considered critical. The rate of loss depends naturally upon the completeness of the obstruction and is proportionate to the amount of vomiting.

*Peristalsis.*—On examination of the abdomen the epigastrium is usually full and the lower half of the abdomen may be sunken. If the skin is bared and the patient placed in a good light the characteristic peristaltic waves are seen. One should not expect to find them if the stomach is empty; they are best seen immediately after taking food or water. When not appearing spontaneously they may often be excited by slight friction or tapping of the epigastrium. There is seen a wave moving slowly from left to right. First a ball-like tumor appears just below the ribs on the left side (Fig. 38). It is usually about one and a half to two inches in diameter and slowly moves toward the right. It disappears just beyond the median line. Sometimes one wave is quickly followed by another. Peristalsis of the intestine, in rare cases, may somewhat resemble these movements; but typical gastric contractions can hardly be mistaken for anything else. After marked peristaltic movements, occasionally with definite symptoms of pain, vomiting frequently occurs. Well defined gastric peristalsis is almost pathognomonic of pyloric or duodenal obstruction. Very small peristaltic waves can occasionally be seen in infants with thin abdominal walls, but they are not to be regarded as significant.

*Pyloric Mass.*—The hardened pylorus can with experience be felt in most instances about one and a half to two inches below the costal margin, just inside the right mammary line, sometimes quite superficially. It usually appears to be about 1 centimeter in diameter and 2 centimeters long. It may be obscured by distention of the stomach or colon or by enlargement of the liver. The pylorus may be displaced, since the gastric enlargement accompanying cases of long standing permits the pylorus a larger radius of excursion from the duodenal attachment; but the direction and course of peristaltic waves aid the examiner in finding it.

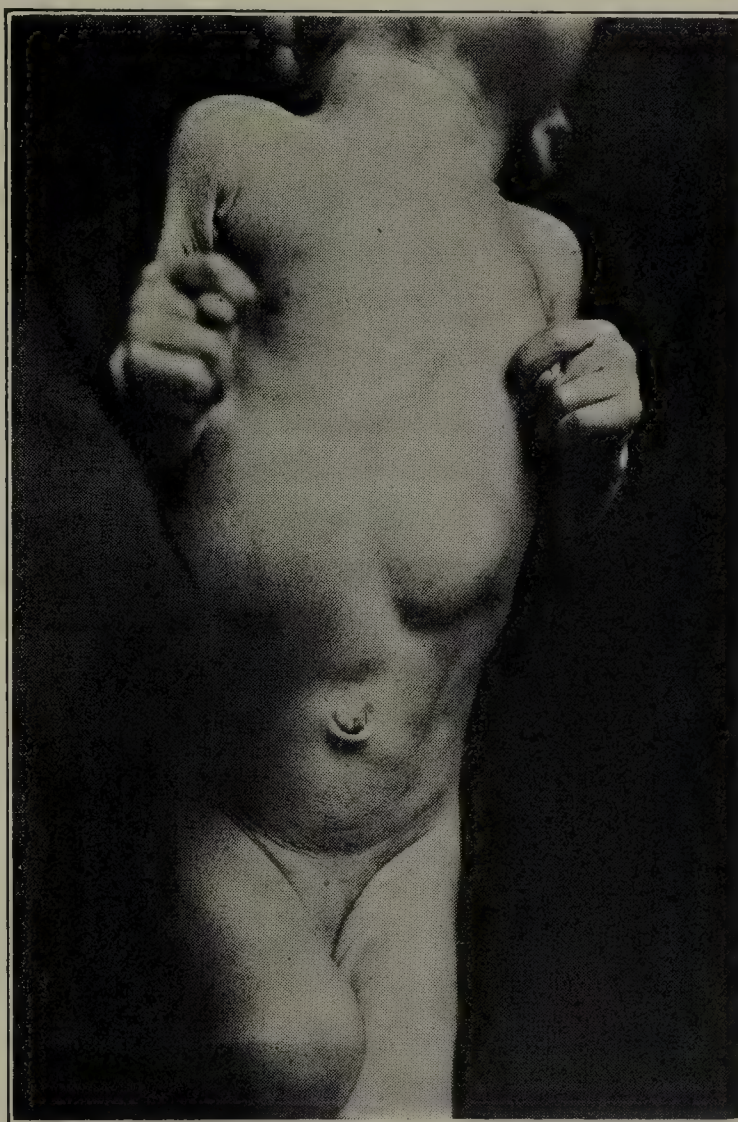


FIG. 38.—GASTRIC PERISTALSIS IN PYLORIC STENOSIS.

Patient eight weeks old. (Thomson.)



It may be felt only during active peristalsis, and when it contracts actively under the examining finger its identity is unmistakable. The character of the tumor is thus more important than its position. It is best felt after vomiting.

*Gastric Retention.*—The prolonged retention of food in the stomach is one of the characteristic features of pyloric stenosis. In healthy nursing infants the stomach is regularly found empty at the end of three hours, often at the end of two hours. But if stenosis is present, food in considerable amount is almost invariably found after three hours and, unless vomiting has occurred, usually after four hours. Sometimes this is also the case if there has been vomiting. This retention varies in amount, but when there has been no vomiting for several hours the amount removed may be even larger than the last feeding taken; after fasting eight or ten hours the stomach may contain three to four ounces (90 to 120 c.c.). Gastric retention is best estimated by the removal of the stomach contents by means of a stomach tube with slight suction. In this way the rapidity with which the food leaves the stomach can be determined quite as accurately as by roentgen-ray examination following a barium feeding.

**Diagnosis.**—This is usually easy after a few days of observation. The history is in most cases characteristic. The diagnostic features on examination are three: waves of gastric peristalsis, abnormal gastric retention and a palpable pyloric mass. The existence of the last is often a matter of uncertainty, but its presence is of considerable positive value. Removal of gas from the stomach by passage of a stomach tube, followed by administration of a feeding to quiet the patient, often aids materially in palpation. Pyloric stenosis has been mistaken for cerebral disease on account of the projectile vomiting and chronic constipation; for renal disease, because of the vomiting and scanty urine. Usually, however, the only difficulty is to distinguish it from functional or habitual vomiting and from vomiting associated with parenteral infection. In the former case, projectile expulsion of the food does not occur and the other essential features of pyloric stenosis are wanting; in the latter, anorexia and other evidences of infection are often present. There are undoubtedly some young infants in whom a temporary pylorospasm occurs, but this condition is quite different from the one we have under consideration. The existence of persistent spasm of the pylorus without hypertrophy has yet to be proven.

Congenital obstruction of the duodenum or other part of the small intestine may lead to persistent, forcible vomiting and, if the obstruction is high up, even to visible gastric peristalsis. But in these cases, whether due to stenosis, atresia, or pressure from bands, the symptoms appear soon after birth and the severe forms are fatal in a few days. The vomitus contains bile, and no pyloric tumor is palpable. The distinction from malposition of the intestines with volvulus may be difficult without exploratory operation. We have seen one patient in whom vomiting, gastric peristalsis, and constipation were due to an ovarian cyst, the removal of which brought about prompt cure of these symptoms.

**Course and Prognosis.**—In the severe form, peristalsis and vomiting are but little influenced by medical treatment; the loss of weight is continuous and often amounts to 2 or 3 ounces (60 to 90 grams) a day; there is very little fecal matter in the stools; unless relieved by operation, the condition generally proves



fatal in from two to four weeks. Sometimes shortly before death there may be, owing apparently to extreme exhaustion of the child, complete relaxation of the spasm with cessation of vomiting and the passage of fecal stools.

In the mild form the symptoms, though characteristic, are all much less marked; gastric peristalsis and a palpable pyloric tumor are present, but the vomiting may be only occasional, fecal stools are passed, the loss of weight is not so marked and there may be periods of improvement in which there is gain in weight. Many of these patients recover without surgical aid, the chief danger being a lowered resistance to intercurrent disease. When medical treatment succeeds, the symptoms gradually abate and by the age of six to eight months all evidence of spasm has disappeared; the patient appears to grow up to fit his enlarged pyloric musculature. The hypertrophy disappears less rapidly. A pyloric tumor has been found at autopsy in children dying of intercurrent disease as long as six months after the disappearance of all symptoms. That there is a chronic form of infantile stenosis which persists into later childhood seems possible, but is not yet established. We have seen one child of eighteen months, in whom the diagnosis was confirmed by operation, although no history could be obtained of any vomiting before the age of eight months.

Statements regarding prognosis will depend much upon the type of case included under the diagnosis. If the term is limited to the cases defined in the beginning of this article, the condition must be considered a serious one, often ending fatally unless properly treated. By older methods of treatment, fully 50 per cent of the children died. At the present time the mortality in most clinics is between 10 and 15 per cent. Most of the deaths are in patients admitted in an almost hopeless condition with severe malnutrition and dehydration. If one excludes these extreme cases the operative mortality is about 5 per cent. The risk of operation is thus little or no greater than the risk of attempting medical treatment. Even successful medical treatment means a prolonged period of convalescence with an increased likelihood of intercurrent infection. In analyzing the cases at the Harriet Lane Home, Davison noted that the average period of hospitalization was nineteen days in patients treated surgically and fifty-three days in those treated medically.

**Treatment.**—The treatment adopted will depend upon the type of case with which we have to deal. With all cases, medical treatment should be given a faithful trial. If the patient is seen early this may safely be continued for a period of at least one or two weeks. With a large proportion of those previously classed as belonging to the mild type, medical treatment will be successful. The cases which are likely to recover usually show decided improvement in a few days—less vomiting, fecal stools, diminished peristalsis and a stationary or slight gain in weight. If, however, when first seen, symptoms have already lasted two or three weeks without material improvement, or if there has been a steady and considerable loss in weight, operation should be advised. Though some of these cases might recover without it, the risks of waiting are greater than the risks of the operation. Again, operation should be resorted to early in all cases classed as the severe type, which fail to show improvement on medical treatment in the course of a few days.

It has been the experience at the Harriet Lane Home in Baltimore that in



about half the cases successful medical treatment is possible; in the remainder resort to surgery has been necessary.

*Medical Treatment.*—This is carried out on the theory that the pyloric spasm to which symptoms are chiefly due will gradually subside if nutrition can be maintained. It consists in diet and stomach washing. If a child is nursing and the mother has sufficient milk, weaning is not advisable. Small meals, not too near together, are essential. The breast should be given at four-hour intervals, and the nursing period varied from two to five minutes, according to the amount obtained. It is often advantageous to pump the breasts and give a measured amount of breast milk; reënfacement of the food by the addition of carbohydrate is then feasible. On no account should an infant be weaned immediately because of the development of the symptoms of pyloric stenosis. For some infants who have been artificially fed nothing succeeds as well as woman's milk. If vomiting occurs and a large part or all of a feeding has been lost the child should be refed; this may be repeated a second time. Refeedings are often retained.

For infants who are artificially fed, concentrated mixtures of whole milk or a thick food (see page 159) are to be advised. Feeding should be regular and not oftener than every four hours. During the period of most active symptoms the patient may not retain enough food to meet his fluid requirements, and parenteral administration of salt solution may be needed.

Stomach washing is at times useful to empty the organ of food and mucus and seems to have some effect in allaying spasm. It should be done about three hours after a feeding, and may be repeated twice in twenty-four hours. If it has a beneficial effect it may be continued for days or weeks.

Atropine in full doses has been recommended to relieve pylorospasm. A 1:1000 dilution of atropine sulphate is used, one drop being given by mouth ten minutes before feeding time and the dosage gradually increased until mydriasis or flushing is observed; this may require as much as thirty drops a day. A somewhat smaller dose is then selected for continuous use. Although excellent results are claimed for this procedure, in our experience it has been unsatisfactory.

It is impossible to foretell what medical treatment can accomplish. Some cases, apparently severe, respond most satisfactorily and promptly to careful feeding. Usually, however, some weeks elapse before any material gain in weight occurs. If loss of weight and vomiting continue uninfluenced, surgical treatment is advisable.

*Surgical Treatment.*—The Fredet-Rammstedt operation is now the accepted procedure. The circular muscular layer of the pylorus is divided externally without opening the mucosa of the stomach. After this is done the pylorus opens and food passes readily into the intestine. The operation can be done under local anesthesia if desired. The operative risk in severe cases has been considerably reduced by postponing interference long enough to overcome dehydration by parenteral administration of fluids.

The after-treatment is exceedingly important and the outcome depends almost as much upon this as upon the operation itself. Feeding may be begun as soon as the child has recovered from the anesthetic. The food, if possible, should be woman's milk. By all possible means should the mother's milk be conserved.



Beginning with 1 or 2 teaspoonfuls (5 or 10 c.c.), it may be given every three hours, alternating with the same amount of water, the amount being gradually increased so that the child at the end of forty-eight hours is usually taking 1 ounce (30 c.c.) or more of milk every four hours, and the same quantity of water between the feedings. At the end of a week the infant may in most cases be put back to the breast, but the amount taken at one time should be limited and the nursing closely watched. In the beginning not over one or two minutes' nursing should be permitted. The vomiting which sometimes occurs for one or two days may be relieved by diminishing the intake of food, by adopting measures to enable the patient to get rid of gas in the stomach, or by the occasional introduction of the stomach tube before feeding.

Since these infants are usually suffering greatly from lack of water and cannot take the needed amount by mouth for some days after operation, parenteral administration of fluids is usually required. Physiological salt solution is indicated; this serves to restore the normal balance of inorganic constituents of the blood.

The shock of operation with most of these patients is surprisingly little. In favorable cases gain in weight begins within a few days after operation and in a few weeks the infant is apparently as well as ever. Patients we have followed for several years do not suffer subsequently from digestive disturbances more frequently than do other children.

## RECURRENT VOMITING

This is a frequent condition and one which is often unrecognized. Although the clinical picture is a definite one, its exact pathology is undetermined. It has also been described under the names *periodic vomiting* and *cyclic vomiting*. It is characterized by periodic attacks of vomiting, which recur at regular or irregular intervals of weeks or months, apparently without any adequate exciting cause. The usual duration of the attacks is two or three days, during which all attempts to control the vomiting are without avail; but at the end of this time it generally ceases spontaneously.

**Etiology.**—The first attacks are usually seen between the ages of two and four years, but they may date back to infancy. The two sexes seem to be almost equally liable. A few of the patients are strong children, but the great majority are rather delicate and of a highly nervous temperament. The cases are seen chiefly in private practice, often occurring among those who have the best surroundings. In most cases the antecedents of patients are of a neurotic type. The attacks are not always traceable to distinct or flagrant errors in diet, and yet the habitual diet seems to bear some relation to the disease. The exciting cause is often a nervous one—great fatigue or unusual excitement, sometimes a railroad journey or a child's party; in many instances it seems to be induced by some minor febrile illness having no relation to the digestive tract, such as an attack of tonsillitis or bronchitis. In children subject to this condition serious diseases, such as scarlet fever or measles, may be ushered in by prolonged and repeated vomiting, which usually ceases before the end of the febrile period. General anesthesia, especially by ether, is very likely to precipitate an attack. The onset of an attack may occa-



sionally follow a short fasting period, at a time when the temperature is normal and when there has been no apparent nervous influence.

These cases have nothing in common with ordinary attacks of indigestion. With our present knowledge they are to be regarded as explosions due to faulty metabolism. The studies of Hilliger upon a child subject to attacks showed that when carbohydrates were withdrawn from the diet the blood sugar fell promptly to half the normal and an attack was precipitated. Normal children were not so affected. The observations have been repeated and extended by Josephs, Ross and others. At the beginning of attacks the blood sugar is low (0.04 to 0.06 per cent), the normal for children being about 0.08 to 0.1 per cent. When the attack is subsiding, the sugar rises to normal limits. The fall in the sugar and the increase in acetone bodies occur much more rapidly than is the case in normal subjects even with complete starvation. There would seem to be, therefore, some temporary interference with the mobilization of glucose, so that it is not immediately available when required. Eventually, with no treatment and with the ingestion of no carbohydrate, in the great majority of cases the blood sugar rises and the inhibitory effect is temporarily in abeyance. There is much similarity between this condition and the effects produced by an excess of insulin. Symptoms develop when the blood sugar is depressed to a certain level. Occasionally convulsions are produced. We have seen more than one child who had convulsions with nearly every attack of vomiting, and similar cases are to be found in the literature.

Wilson, Levine and Rivkin studied the respiratory metabolism in a case of cyclic vomiting, and noted an increased combustion of fat as compared with the normal subject on a similar diet. They are inclined to view cyclic vomiting as a primary disorder of fat metabolism. They point out that the normal child shows ketosis more readily than the adult, and suggest that in cyclic vomiting there is an exaggeration of this tendency.

**Symptoms.**—The clinical picture presented by these cases is very characteristic, and is well illustrated by the following history:

The patient was a well-nourished boy of six years when he first came under treatment. He belonged to a neurotic family, and the attacks dated back from infancy. From this time they had recurred usually at intervals of a few months; occasionally five or six months would pass without one. The symptoms in all the attacks were similar in kind, differing only in degree. They were preceded by a prodromal period lasting from twelve to twenty-four hours, marked by languor, dullness, dark rings under the eyes, loss of appetite, and a general sense of discomfort in the epigastrium. At this time the temperature was generally slightly elevated. The vomiting then began suddenly. It was attended with great retching and distress; it was often repeated every half-hour or hour for two days. On one occasion it occurred seventeen times in a single night. Vomiting was immediately excited by the taking of any food or drink, but it occurred also when nothing was taken. The vomited matter consisted of frothy mucus and watery material, frequently streaked with blood, apparently from the violence of the emesis, and often containing bile. The temperature usually fell to about 100° F. when the vomiting began, and continued at or below this point throughout the attack. By the end of the second day the exhaustion was very marked—so severe, in fact, as apparently to threaten life. The child lay in a semistupor, with eyes half open, lips and tongue dry, rousing at times to beg for water. The pulse was rapid and weak, and sometimes slightly irregular. There was no distention of the abdomen; it was usually flattened. By the third day the



vomiting became less frequent and then ceased entirely. Convalescence was rapid, and by the end of the week the boy was almost as well as usual. The attacks continued to recur at gradually lengthening intervals until they finally ceased altogether at about the twelfth year.

A considerable number of these cases come under observation. The usual duration of the attacks is one to three days. In one child they lasted regularly for five days. Severe attacks sometimes last over a week. The average number of attacks is four or five a year.

Prodromal symptoms are present in most of them—headache, general languor, coated tongue, and anorexia are the most frequent; in some there is marked constipation, with a history of very white stools for some time. But it is not uncommon for an attack to occur in the midst of apparently perfect health. The tongue is usually coated at the beginning of an attack, and at its height it is often dry and brown. The abdomen seems empty and its walls sunken; pain and tenderness are both rare. The bowels are usually constipated and move only with difficulty by artificial means. Very exceptionally there may be diarrhea with foul stools.

There is, as a rule, no desire for food, but the continual cry is for water to quench the constant, burning thirst. The pulse after the second day becomes rapid, soft, and often somewhat irregular. The respiration is shallow, and at times this also may be irregular. The temperature is usually under  $100.5^{\circ}$  F., rarely it may be  $102^{\circ}$  or  $103^{\circ}$  F. The low temperature is a point of much diagnostic value. The patients are dull, apathetic, and wish to be left alone. Headache is very common.

The disposition to vomit is sometimes so great that patients are afraid to move or even to talk lest it may be provoked. The vomited matter is often large in amount, considering that the patient is fasting. It is essentially gastric juice, containing free hydrochloric acid, mucus, usually considerable bile, and often traces of blood. Less frequently vomiting may occur only two or three times a day. The urine is concentrated, and frequently contains at the height of the attack a trace of albumin, a few hyaline casts, and some blood cells. As the condition improves the renal secretion increases. A condition practically constant, and first pointed out by Marfan, is the presence of acetone bodies in the urine. These often appear in the urine in large amounts so early in the attack that they cannot be ascribed to ordinary starvation, and therefore may be of diagnostic value.

It should be emphasized that acetonuria does not mean that an acetone-body acidosis is present; the latter is uncommon in cyclic vomiting, for the production of abnormal acids is compensated for by the marked loss of acid in the vomitus. It is only in occasional instances, usually cases complicated by diarrhea, that a true *acetone-body acidosis* develops. The attack may begin with vomiting, but this is not so striking, and is often masked by the development of great prostration and hyperpnea. The child is extremely restless, often delirious and eventually comatose. The temperature is usually elevated ( $102^{\circ}$  to  $103^{\circ}$  F.). The tongue is heavily coated and dry. There may be an odor of acetone to the breath. The pulse is rapid and feeble. The respirations are very deep but not rapid and the excursions of the chest much increased. The urine is scanty and contains acetone bodies in



large amount. The bicarbonate of the blood is greatly reduced and also the blood sugar. Unless energetically treated such cases may terminate fatally in the course of two or three days. Such attacks are seen even in infants. There can be little doubt that they are of the same nature and depend upon the same causes as the more usual forms of recurrent vomiting in older children. The diagnosis is usually not made and other conditions are considered on account of the occurrence of the symptoms in infancy, the great severity and rapidity of progress and the pronounced nervous symptoms.

**Prognosis.**—Although these patients very often seem to be most alarmingly ill, the danger to life is slight, except with infants or young and feeble children. We have seen but 3 fatal cases, and in one the diagnosis is open to question, as no autopsy could be obtained. Griffith reports 2 fatal cases, the autopsy in one showing nothing definite. The probabilities are always in favor of a recurrence of the attacks. In most of the patients who have been observed they have extended over a series of several years, although by a careful regimen much could be done to reduce their frequency and diminish their severity. In a considerable proportion of cases they may be stopped altogether. Toward puberty there appears to be a strong tendency to spontaneous recovery. We have never seen a case in a child over fourteen.

**Diagnosis.**—Organic disease of the brain and kidneys must be excluded. The first attacks witnessed may strongly suggest the onset of tuberculous meningitis, and only the course of the symptoms may show that this is not present. Usually a history of many previous attacks may be obtained.

From acute indigestion, recurrent vomiting is differentiated by the fact that the attacks are not brought on by indigestible food, and also by the persistence of the vomiting, and the early presence in the urine of the acetone bodies.

Appendicitis is excluded by the absence of pain, tenderness, and muscular rigidity; intussusception by the fact that the symptoms are less severe, by the absence of blood and mucus from the stools, and by the fact that intussusception is usually seen in infancy.

**Treatment.**—When the premonitory symptoms appear, the child should be put to bed and removed, so far as possible, from all sources of emotional stimulation. The repeated administration of small quantities of orange juice containing sugar offers some prospect of aborting an attack, but in actual experience this can rarely be done. When the vomiting has once begun, it is only aggravated by the taking of food or drink or by any medication by the mouth, and all efforts in this direction should be suspended. Cracked ice may, however, be offered freely. Rectal administration of sodium bromide (approximately two-tenths of a grain per pound of body weight, or 30 milligrams per kilogram) is of great value in bringing the nausea and retching under control. In cases which are seen at the outset it is usually possible to prevent dehydration by rectal or subcutaneous administration of fluids. For severe dehydration with distressing thirst an intravenous infusion of normal saline solution or of 5 per cent glucose in normal saline is to be preferred. Other routes of fluid administration operate less dramatically under these circumstances. It is impossible to predict the exact quantity of fluid that will be required in a given case; the amount needed is that which will relieve thirst and



establish a copious diuresis. One seldom needs to resort to alkalis for control of acidosis if the above regimen has been followed.

When the vomiting has ceased for several hours it is not likely to recur if food is judiciously administered in small quantities. Hard candy or dry crackers without butter are often well tolerated at first, and help to stem the faulty combustion of fats which is at the basis of the ketosis.

Between the attacks, the diet should consist principally of meat, vegetables, skimmed milk, cereals in moderate amount, cooked fruit and stale bread—in other words, a diet poor in fat. In addition to careful regulation of food, the general nutrition should be considered, and the patient's life so regulated that extreme fatigue and exhaustion, as well as nervous excitement, are prevented.

### ACUTE GASTRITIS

Inflammatory lesions of the stomach are comparatively uncommon in early life. They may result from infection or from the introduction of irritant drugs or poisons.

**Infectious Gastritis.**—This may occur in connection with an acute gastrointestinal upset, usually associated with a parenteral infection. The pathological changes are usually confined to the mucosa, which is the seat of a catarrhal inflammation. Ulcerative gastritis was met with six times, excluding tuberculous cases, in 390 consecutive autopsies in infants at the Babies' Hospital. Usually ten or fifteen ulcers were present, being distributed principally at the pyloric end and along the greater curvature. They seldom extended to the muscular, never to the peritoneal coat. Membranous gastritis is a very rare lesion; it may be associated with diphtheria, bacillary dysentery, streptococcus infections of the pharynx, or may occur without relation to these factors.

There is no characteristic clinical picture. Vomiting with or without the production of mucus may be fully as pronounced in patients who show no gastritis at autopsy. Even cases of the ulcerative form rarely show hemorrhage. It is the rule rather than the exception for these cases to be discovered only at the post-mortem table.

**Corrosive Gastritis.**—The usual cause of this is the swallowing of caustic alkalis. Less frequently ammonia, carbolic acid and other corrosive substances are responsible. The lesions in the stomach are much influenced by the quantity and concentration of the irritant and the quantity of food in the stomach. Strong caustics usually act more intensely in the pharynx and esophagus, for owing to spasm of the muscles of these parts, often little reaches the stomach. The gastric lesions may affect the mucous membrane diffusely or may produce irregular ulcerations, especially along the greater curvature. Perforation may occur. In severe cases death takes place within a few hours; dark, ragged ulcers are found, the surrounding mucosa being intensely congested, with extravasations in places. If death is delayed there is intense inflammation often with the production of pseudomembrane. Recovery may result in a cicatricial contraction of the stomach with partial obstruction.

The immediate symptoms are intense pain, a sense of constriction in the throat and vomitus which is bloody. The effects of the caustic may be seen in the mouth.



Collapse follows rapidly. If the patient survives, an acute gastritis persists for some time, and often an enteritis as well. Dehydration constitutes a serious problem.

Treatment consists in early gastric lavage. If an hour or more has elapsed, this is, however, quite useless, and therapy should be confined to the treatment of pain and shock and the prevention of esophageal stricture (see page 368).

### CHRONIC GASTRIC INDIGESTION—"CHRONIC GASTRITIS"

In many patients with chronic indigestion lasting several months, the predominant symptoms may be of a sort to suggest that the fault lies primarily with the stomach, even that it may be the seat of an organic lesion. This is true particularly when anorexia, nausea, capricious appetite, belching, regurgitation, sensations of burning and fullness in the epigastrium, and vomiting, especially when this is accompanied by large amounts of mucus, characterize the picture. An easily demonstrable dilatation of the stomach lends added weight to this interpretation. There is almost invariably an associated neurotic element, and it is often difficult to decide with certainty whether this plays a primary or secondary rôle. Few of these patients come to autopsy, although they may show marked malnutrition and a lowered resistance to infectious disease; during spells of fever associated with infections it is not uncommon for their gastric symptoms to abate, though the reverse may be the case.

Clinical studies usually demonstrate definite alterations of gastric function. Lavage shows the stomach capacity to be abnormally large and the formation of mucus excessive. Hypochlorhydria or achlorhydria is present. The motor function is feeble and the emptying time may be prolonged for several hours. Constipation is generally present, though there may be periods of diarrhea. The stools tend to be pale, and to contain undigested food.

In point of fact, the dependence of these symptoms on an organic lesion of the stomach is rare. The vast majority of such patients show at autopsy nothing beyond simple dilatation; and, vice versa, when true chronic gastritis is discovered it is rarely associated with even a suggestive symptomatology. We have in a few instances seen this picture associated with mechanical causes of obstruction. One patient was promptly cured by removal of a gastric papilloma discovered by gastroscopy; another, by section of peritoneal bands. Such cases are exceedingly rare.

In the study of these patients a careful history, in which particular attention is paid to the time of onset and the course of development of the symptoms, is of the greatest help in determining whether the symptoms are due to congenital malformation, to a postnatal inflammatory condition, or to neurosis. The rare cases of mechanical obstruction as a rule give symptoms practically from birth on, and the appetite is less likely to suffer. In the great majority the symptoms begin—or, at least, begin to be troublesome—after the age of two years; and by the same token the great majority are of functional origin. Physical examination as ordinarily performed is of little assistance; patients with a purely functional disturbance are about as likely to show dilatation of the stomach and visible peristalsis as those with an organic obstruction. One must endeavor by the use of tests of gastric motor function to determine whether a mechanical cause is present, for only in these cases is surgical intervention justified, and here it is directly indicated.



Analysis of the fasting contents, the response to a test meal, and the x-ray are the principal adjuvants to the establishment of an anatomical diagnosis; in certain cases, and in skillful hands, gastroscopy gives definite information.

The treatment of cases of purely functional nervous origin and of those in which inflammatory involvement of the stomach is suspected is the same. It has already been outlined in the section on Nutrition in the chapter on Malnutrition. The principles are simple. A diet is chosen from the foods appropriate to a healthy child of the same age, with due regard for normal requirements of the various components. Within these limits, its variety may be as great or as small as appears to be most successful in the individual case. Medication of any sort is suspended. Due attention must be paid to general hygiene, including such factors as fresh air, sunlight, the avoidance of overdressing both day and night, and the protection from contact infections. Feeble patients may derive benefit from massage. For ambulatory patients the temporary use of an abdominal binder or supporting belt has many advocates. But most important of all is the creation of a normal emotional environment. This usually calls for separation of the patient from over-anxious parents, and removal from his home. A short period of hospitalization is often needed in the proper study of these cases, but as a rule they should not be kept there for long but put in charge of a competent nurse and given a complete change of scene. Association with normal, healthy children is most helpful.

The following is an example of chronic gastric indigestion developing on a neurotic basis:

Sally G. was brought to the Harriet Lane Home at four years of age because of malnutrition, poor appetite and spells of vomiting. Though normal at birth she had fallen below the average weight by the end of the first year; there was no unusual history of infections. She had never been interested in food, had always been nervous and high-strung. The vomiting commenced at the age of three. Every ten days or so she would wake up at night and vomit for about twenty minutes; the next morning she would feel as well as ever. By restricting the diet to simple foods—milk, cream, eggs and cereal—the vomiting could be decreased but not eliminated. The appetite was poor, meals being eaten only after coaxing and bribing. She complained of epigastric pain after eating. Laxatives were given daily.

On admission the patient was found to be 16 per cent underweight for her height. Her general attitude was one of apathy and invalidism. The tonsils were large and congested and there was enlargement of the regional lymph nodes. The tongue was coated. The stomach was distended and from time to time gastric peristalsis could be observed through the thin abdominal wall. The stools contained considerable mucus, but were otherwise negative. Gastric analysis showed a moderate amount of mucus and absence of free hydrochloric acid. Fluoroscopy revealed a large atonic stomach emptying itself rather slowly; there was a filling defect at the pylorus which was interpreted as being due to spasm.

The tonsils were removed during her stay in the hospital. The patient was then sent to a country convalescent home where she could associate with other children and be away from her parents. The change was immediate. There was no further vomiting; she at once took an interest in life, ate heartily and played actively and normally. Within four weeks she had gained over four pounds. She volunteered the information that she didn't eat at home because she was always fussed over by her mother and grandmother. Apparently too, she had resented the adulation showered on a younger sister.



### DILATATION OF THE STOMACH

Moderate dilatation of the stomach is quite a frequent condition, but it is not a large factor in the common disorders of digestion in infancy and childhood. A very marked degree of dilatation is occasionally met with, the recognition of which is usually easy but the treatment difficult. Dilatation is in most cases regular or cylindrical; it is usually most marked at the cardiac extremity. Cases of irregular dilatation, like the "fish-hook" stomach, are sometimes encountered even in early life, but are rare as compared with their occurrence in adults. Dilatation may result from hypertrophic stenosis of the pylorus. The most important predisposing cause, however, is the muscular atony which accompanies rickets. It is found to some degree in almost all marked cases of rickets. The principal exciting causes are chronic indigestion and distention from overfeeding.

In most cases the only symptoms are those of the chronic indigestion which almost invariably accompanies dilatation. The vomiting seen with dilatation is peculiar in that it is infrequent, possibly only once a day, but then the quantity vomited is larger than the last meal taken. In young infants the pressure symptoms resulting from acute dilatation may be very serious. This is particularly true of those with acute bronchitis or bronchopneumonia, or atelectasis. In such patients we have seen grave symptoms accompany the rapid distention of a dilated stomach, and in one very delicate infant of three months this was apparently the cause of death. The diagnosis of dilatation may be made by physical signs and by x-ray. There is epigastric fullness and distention, and in some thin patients the outline of the stomach can be distinctly seen. Inflation of the transverse colon, however, may be mistaken for dilatation of the stomach. Valuable information is obtained by percussion, particularly after filling the stomach with air or water by tube. If the lower border comes below the umbilicus, it may be assumed that the stomach is dilated. More accurate information can be obtained by the x-ray after a barium meal. The stomach does not empty in the normal time and often the presence of food may be demonstrated seven or eight hours after ingestion.

In acute dilatation of the stomach accompanying infections, particularly pneumonia, the distention may be relieved by passage of a stomach tube, but it is likely to recur. The prognosis here depends on the patient's response to the primary condition. In chronic dilatation of moderate degree, the prognosis is good provided the underlying factors are appropriately dealt with. Severe cases of long duration usually accompany the clinical picture of chronic gastric indigestion just discussed. Dilatation may persist for months after other symptoms have begun to subside under proper treatment, but the ultimate prognosis is favorable. Here again, the treatment is that of the underlying condition. In chronic dilatation accompanying visceroptosis an abdominal support may be worn with benefit for a few weeks or months. Daily lavage may be ill-advised and only add to the neurotic element of the syndrome.

### ULCER OF THE STOMACH

Ulceration of the stomach may be found in connection with several pathological processes which are quite distinct from one another:



*Ulcers in the Newly Born.*—These have already been referred to in the chapter on Hemorrhages of the Newly Born. The only characteristic symptom is hemorrhage.

*Ulcers Resulting from Acute Gastritis.*—These also are not frequent. As a rule they give no specific symptoms, although in several cases we have known severe hemorrhage to result from them. This symptom will be considered later.

*Tuberculous Ulcers.*—These are quite rare. We met with gastric ulcers 5 times in 119 consecutive autopsies on tuberculous cases; the evidence was not conclusive in all of them that the ulcers were tuberculous, but in 3 the tubercle bacilli were found. Usually there were several small ulcers; in one case but two were present, the larger one being nearly three-fourths of an inch in diameter, and situated on the posterior wall near the middle of the great curvature. All but one of these cases were in infants, one child being only ten months old. The ulcers gave no symptoms during life, and death took place from general tuberculosis. This is the history of nearly all the few cases on record. In one, however, reported by Cazin, a tuberculous ulcer perforated the stomach and caused death from peritonitis.

*Simple Perforating Ulcers.*—In young children these are of great rarity and uncertain pathology; they have been observed even in early infancy.

The symptoms of ulcer before perforation are gastric pain and tenderness, vomiting of blood, and often bloody stools. In most of these cases in children there were no symptoms until perforation; then followed collapse, sometimes high temperature, the rapid development of tympanites, and death from shock or from peritonitis.

The prognosis is bad in all forms of ulcer of the stomach, except the small follicular variety. In this, however, the diagnosis cannot be made except by gastric hemorrhage, and it is only this which makes these cases serious.

The treatment is absolute rest, ice by mouth, small doses of opium, and rectal feeding. If symptoms of perforation occur the abdomen should be opened without delay, as offering the only chance of recovery.

## TUMORS OF THE STOMACH

Although exceedingly rare, tumors of the stomach occur in childhood, and are seen even in infancy. Primary sarcomata and lymphadenomata have been reported.

Six cases of carcinoma of the stomach in children under ten years are collected in an article by Osler and McCrae. Four of these were in young infants and probably congenital. One case, in a child of eight, presented the usual symptoms and lesions of the adult disease.

## HEMATEMESIS

The most frequent variety of hemorrhage from the stomach, that in the newly born, has already been considered.

Serious and even fatal cases of gastric hemorrhage, though extremely rare, may be seen in older infants. The source of the bleeding may be small capillary hemorrhages from the mucous membrane, it may be from single or multiple ulcers of the stomach, or more frequently from duodenal ulcers.



Hematemesis may occur in purpura, hemophilia, scurvy, Banti's disease, cirrhosis of the liver, thrombosis of the portal or splenic vein, congenital esophageal varices, phosphorus poisoning, and rarely in malaria. In young girls about puberty it may be a form of vicarious menstruation. Occasionally blood may be vomited in cases of hemorrhagic measles. Two cases are reported in which fatal hemorrhage followed the swallowing of a foreign body. In both, vomiting of blood occurred long after the original accident. In one case two and a half years had elapsed. The autopsy in this case showed impaction of the foreign body and ulceration into the arch of the aorta. Spurious hemorrhages may occur when blood has been swallowed and then vomited. The source of this is most frequently the nose or pharynx. It may happen in infants at the breast, when the blood is drawn from a fissure or ulcer in the nipple. The amount of blood vomited under these circumstances may be large enough to be quite alarming. It may be recognized by the child's general condition being normal, and by the presence of fissures or ulcers upon the nipple. It may sometimes be noticed that the vomiting of blood follows nursing from one breast and not from the other.

**Symptoms.**—There may be no symptoms except those of internal hemorrhage, but this is rare. Usually there is vomiting of blood, and blood appears in the stools. If the hemorrhage is rapid and vomiting speedily occurs, the blood may be of a bright-red color. If it has been long in the stomach it is of a dark-brown or black color resembling coffee-grounds. The stools containing blood from the stomach are black and tarry in appearance if the bleeding is extensive; if not, only chemical tests show its presence. The general symptoms will depend upon the amount of blood lost.

In a case where blood is vomited, the first point is to distinguish spurious from true gastric hemorrhage. The nose and pharynx, especially its posterior wall, should be carefully examined. If the child is at the breast, the nipples should be examined. In older children it is important to distinguish vomiting of blood from hemoptysis. This distinction is to be made in accordance with the rules laid down in textbooks on general medicine. The prognosis is bad if the hemorrhage is due to ulcer, if it is very profuse, or if it occurs in young infants. When it occurs in connection with constitutional diseases the prognosis depends upon the original disease.

**Treatment.**—The patient should be kept quiet, with morphine, if necessary; if there are signs of collapse, stimulants may be given hypodermically or by the rectum. No food or water should be given by the stomach for at least twenty-four hours after the hemorrhage has ceased. The pulse should be carefully watched. Parenteral fluid administration need not be forced, but should control thirst. When the general condition is poor or the hemoglobin has fallen rapidly, a transfusion should be given. Transfusions given early, before bleeding has ceased, sometimes appear to aggravate the condition.

### THE SWALLOWING OF FOREIGN BODIES

Between the ages of one and four years particularly, the habit of swallowing foreign substances is a very common one. The variety of objects swallowed includes all those articles which the young child can reach and put into his mouth.



The most common are detached parts of toys, marbles, pebbles, buttons, and coins. Not only are such smooth articles swallowed, but also with equal readiness, sharp ones, such as pins of every variety, bits of glass, fragments of bone, nails, and small toy knives and forks, etc. At the time of swallowing, choking attacks, severe pharyngeal pain, and sometimes slight hemorrhage may occur. Symptoms referable to the esophagus or stomach are very few. During passage of the object through the intestine there may be colicky pains, but in the majority of instances there are no symptoms whatever even with sharp or angular bodies. Impaction and perforation, while possible, are surprisingly rare. The usual time required for a foreign body to traverse the intestinal tract is from four to twelve days, but it may be considerably longer. We have known a safety pin to be retained in the intestinal tract for eight months without producing any symptoms, and then passed spontaneously; its presence in the stomach was demonstrated by the x-ray two hours after it was swallowed. If the body swallowed is a smooth one, it passes the anus without difficulty. But with sharp bodies there may be severe pain and sometimes hemorrhage.

The diagnosis is often a matter of much difficulty, and without an x-ray examination a positive diagnosis is impossible. Very often when the physician is called because this condition is suspected by parents the alarm turns out to be a false one.

It is most surprising to see the size, variety, and dangerous character of the foreign bodies which pass through the intestinal tract without causing any symptoms whatever. Expectant treatment is therefore by all means to be recommended. No emetics or cathartics should be administered. The diet need not be changed. Most of all, operation should not be performed or even considered unless there are definite local symptoms, as perforation or serious inflammation is extremely rare.

Quite distinct from such accidental swallowing of foreign substances as has just been described, is the practice of pulling off and swallowing hair, fur from rugs, wool from toys or blankets, shreds from clothing, and a great variety of other substances. This habit is usually seen in nervous children, and often in those where some gastric irritation seems to excite an abnormal craving. In infants the quantity of the substance is generally small, and usually it provokes vomiting or the material is speedily passed by the bowel. In the Babies' Hospital a colored child of about eighteen months passed in one day a large mass of hair which she had pulled from her own head. Another child pulled into shreds and swallowed a large portion of the foot of a cotton stocking, and passed the same by the bowel the following day.

It occasionally happens that the substance swallowed does not pass the bowel but forms an intestinal tumor which may give rise to obscure and sometimes to severe symptoms of long duration. But more often the tumor forms in the stomach. These gastric tumors are usually composed of hair from the patient's own head. They are more frequently seen in older children than in infants, and usually in girls on account of their long hair. Many of these patients are of the neuropathic type. The habit may continue until a tumor of considerable size forms, sometimes attaining 2 or 3 pounds in weight.



The symptoms of *hair ball in the stomach* are vague until the tumor is discovered. There are usually gastric disturbances of a rather indefinite character. Epigastric pain is common, but vomiting is not especially marked. The general health may suffer but little for a long time. The tumor may be mistaken for cancer, a displaced spleen or kidney, fecal impaction, or a tumor of the omentum. A correct diagnosis is seldom made until operation is performed. In a few instances the tumor has disappeared after catharsis. With operation the outcome is almost always favorable.

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## CHAPTER XXX

### DISEASES OF THE INTESTINES

#### MALFORMATIONS AND MALPOSITIONS

Malformations are not very frequent, but are of great variety, being met with at any point in the canal, most frequently in the rectum and anus. Gärtner collected 38 cases in which the seat of obstruction was above the rectum; of these, the duodenum was involved in 19 cases, the jejunum in 3, the ileum in 11, the colon in 6, the ileum and colon in 1. The concurrence of multiple deformities in many cases diminishes the number in which surgical intervention is likely to be successful.

**Malformations of the Duodenum.**—Atresia is more often seen than stenosis, and in the majority of cases the obstruction is located below the papilla of Vater. The cause of the defect usually lies in faulty canalization of the gut in early fetal life, resulting in partial or complete obstruction of the lumen by a curtain or membrane. More rarely an appreciable segment of the duodenum is represented merely by a solid cord, or there may be complete separation of the upper and lower portions. In some cases probably dependent on antenatal peritonitis the gut is kinked or compressed by peritoneal bands. Vomiting appears early and in most cases is bilious—points of differentiation from pyloric stenosis. The two conditions resemble each other in showing projectile vomiting, visible gastric peristalsis, gastric dilatation, failing nutrition, and constipation. Sometimes the distended portion of duodenum above the obstruction may be palpated as a soft mass, but usually nothing abnormal can be felt. With the x-ray the duodenal pouch can often be visualized. It is easily mistaken for the pyloric portion of an hour-glass stomach. The absence of lanugo hairs from the fecal discharges, on microscopic examination, is of some help in identifying cases of complete occlusion. The more complete the obstruction, the more severe are the general symptoms. Cases of true atresia seldom live long enough for the correct establishment of diagnosis before death. Within recent years an appreciable number of patients with partial obstruction have been successfully relieved by operation—gastro-enterostomy or, in suitable cases, section of constricting bands.

**Malformations of the Intestine.**—There may be stenosis or, more commonly, atresia at any point, often at many points. Obstruction is much more frequent in the upper than in the lower part of the small intestine. The lumen is usually obliterated for a considerable distance, the intestine being represented only by a fibrous cord which connects the two open portions, or there may be no connection between them. In all cases the intestine above is found greatly distended, while that below is empty and usually atrophied. Multiple obliterations may accompany congenital volvulus. The prognosis for successful surgical interference is poor.



*Congenital Volvulus.*—In one form of this condition some portion of the intestine is compressed or kinked by peritoneal bands, of presumably antenatal inflammatory origin. Another form represents a simple maldevelopment. Early in fetal life the cecum normally crosses the abdomen from left to right, moving anteriorly to the superior mesenteric artery, so that by the fourth month of intra-uterine life it lies in the right upper quadrant. With subsequent growth of the large intestine the cecum descends into the right lower quadrant and becomes fixed in its normal position by fusion of its mesentery with the posterior parietal peritoneum, the transverse colon meanwhile becoming attached to the stomach by the transverse mesocolon. By failure of this normal sequence of events the cecum may lie in the left upper quadrant, or after crossing over may remain in the right upper quadrant, or it may have passed behind the superior mesenteric artery. In any of these eventualities there is an abnormal degree of mobility of the large intestine—particularly of the cecum and ascending colon—and an increased opportunity for kinking of the gut or twisting of the mesentery with strangulation of the blood supply. The common clinical picture of congenital volvulus is one of acute obstruction at the second or third portion of the duodenum, with bilious vomiting, constipation, and rapid wasting. Symptoms may appear in the first few days of life or may be delayed. A few patients have been cured by surgical means.

*Meckel's Diverticulum.*—This is the remains of the omphalomesenteric duct, which in fetal life forms a communication between the intestine and the umbilical vesicle. It is given off from the ileum, usually about a foot above the ileocecal valve. Most frequently it exists as a blind pouch from  $\frac{1}{2}$  to 2 or 3 inches long, communicating with the intestine. At the extremity of this there may be a fibrous cord, which is free in the abdominal cavity or attached to the umbilicus. In other cases the duct may remain pervious quite to the umbilicus, so that there is a fecal fistula. Prolapse of the mucous membrane of the duct may lead to an umbilical tumor, described elsewhere. A persistent Meckel's diverticulum usually gives rise to no symptoms, but when present as a cord connecting the ileum with the umbilicus may compress a coil of intestine, leading to obstruction or even strangulation. This may occur in infancy or later in life. Cases of intestinal hemorrhage from a peptic ulcer in a Meckel's diverticulum have been described. Parasites have been known to lodge here.

**Malpositions.**—The ascending colon may be found upon the left side. There may be a complete transposition of the abdominal viscera. In cases of congenital umbilical hernia a large part of the intestines may be found in the tumor, and in diaphragmatic hernia they may be in the thoracic cavity.

## DUODENAL ULCER

These ulcers were once considered very rare in infancy and early childhood, but the increasing number of cases reported, especially since 1908, indicates that they had formerly been overlooked. From a study of 95 cases in infants under one year collected from the literature in 1913, the conclusions which follow have been drawn.

Duodenal ulcers are much more common than gastric ulcers; according to Ent:



they outnumber them 10 to 1. We have never seen an instance of peptic ulcer of the stomach in infancy. Seventy per cent of the reported cases of duodenal ulcer have been observed between the ages of six weeks and five months; about 10 per cent occur in the newly born. The great majority of the cases have been seen in infants of the atrophic type. In most of them there has been also a history of previous digestive disorders. In several cases duodenal ulcers have been associated with spasm of the pylorus.

The most frequent site of the ulcer is on the posterior wall of the duodenum and practically all are above the papilla. When but a single ulcer is present, as is true of about two-thirds of the cases, it is nearly always situated just below the pyloric ring. These ulcers are circular in shape; they have shelving, sharply defined edges, usually described as "punched-out" in appearance. At the base, blood vessels of considerable size are often seen. The ulcer may involve the mucous membrane only, in which case it may readily be overlooked, or it may go to the muscular coat, to the peritoneum or may even perforate. Microscopical examination shows almost complete absence of round-cell infiltration and other evidence of inflammatory reaction. The rest of the duodenum usually shows a normal mucous membrane or one simply blood-stained. Large clots of fresh blood may be found in the duodenum or in any part of the small or large intestine. The stomach also may contain old or fresh blood.

In over one-third of the recorded cases no symptoms suggestive of the condition were present, the ulcer being found at autopsy in patients dying from other causes. In other cases death occurs suddenly in collapse, sometimes preceded by symptoms of an ordinary gastro-intestinal disturbance and sometimes by none at all. In such cases the autopsy frequently discloses severe concealed hemorrhage or perforation. If life is prolonged, peritonitis may follow, but its recognition under these circumstances is exceedingly difficult, since vomiting, fever and distention may all be wanting. Localized pain and tenderness in patients of this age are of no assistance in the diagnosis, although they are valuable symptoms in older children.

The only definite symptom pointing to duodenal ulcer is hemorrhage. Blood may be vomited or passed in the stools. In 64 cases of ulcer reported with good histories, bloody stools were observed in 28, bloody vomiting in 10 and both in 6 cases, 4 of these being in the newly born. Fresh blood may be seen or blood changed by the action of the stomach or intestine. Once it occurs, hemorrhage is apt to continue until the death of the patient, usually in twenty-four to thirty-six hours. The appearance of blood in any considerable amount in the stools should always suggest duodenal ulcer. Jaundice was a symptom in but 1 case in the series.

The diagnosis is made mainly by the presence of hemorrhage from the stomach or intestine, usually associated with collapse. Perforative peritonitis may be due to appendicitis as well as ulcer, and both intestinal hemorrhage and collapse may occur with intussusception. These should be borne in mind as two conditions easily confounded with duodenal ulcer. Polyps, hemorrhoids, and colitis must also be excluded. The prognosis of duodenal ulcer at present is very bad. The finding of healed ulcers at autopsy proves that recovery does sometimes take place, but it must be considered rare.



The treatment is purely symptomatic; on account of the present uncertainty of diagnosis, surgical measures are rarely justifiable.

## ENTERITIS AND COLITIS

Specific infections of the intestinal tract—bacillary and amebic dysentery, typhoid, paratyphoid, and tuberculosis—are considered elsewhere. Nonspecific enteritis has already been discussed in the article on diarrhea. Here will be considered two forms of nonspecific chronic intestinal disturbance occasionally met with in children.

**Spastic Constipation ("Spastic Colitis").**—This is an uncommon condition in childhood and is very rare in infancy, though we have seen an undoubted instance in a child of three months. There is no characteristic organic pathology, the syndrome being usually attributed to autonomic imbalance. It may be accompanied by other manifestations of a neuropathic constitution; abdominal pain may be complained of, and many of these patients vomit readily.

There is usually a history of constipation which has proved resistant to diets high in residue. The stools may be normal, but not infrequently they consist of small, round, firm scybala, or are passed as slender pencil- or ribbon-like masses; some mucus may be present. At times the spastic portions of the colon can be palpated through the abdominal wall, but as a rule one must rely upon an x-ray examination to confirm the diagnosis.

A barium enema gives more information than barium given by mouth. Difficulty is often encountered in introducing an enema. Fluoroscopy after the introduction of the opaque material usually reveals hypermotility of the colon, but this cannot be regarded as significant unless it persists. Psychic factors exercise a profound influence on motility, particularly in children, and this response may be due only to the excitement or apprehension caused by the unaccustomed procedure. The characteristic finding is the presence of one or more areas, usually in the descending or transverse colon, in which the lumen is greatly constricted by strong muscular contraction and the haustrations stand out very prominently. In sharp contrast to these spastic portions is the dilated gut on either side of them, in which the haustrations are far less conspicuous. The spastic areas are usually from 2 to 4 inches in length, but may involve the entire transverse colon. They persist at a definite location during a fluoroscopic examination, but if examinations are repeated they are just as likely to be found in other parts of the colon. Valuable confirmatory evidence can be obtained by examining the patient immediately after the enema has been discharged (see Fig. 39); a considerable amount of barium is often retained in the portion above an area of spasm, whereas the area itself is comparatively free from opaque material. Traces of barium not infrequently persist for twenty-four or forty-eight hours after its introduction in these cases.

The spastic colon should not be confused with the normal condition, a mistake readily made unless one is familiar with the normal fluoroscopic appearance of the colon in young subjects.<sup>1</sup> On the other hand, it is to be distinguished from chronic

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<sup>1</sup> The x-ray appearance of the colon differs greatly, depending on whether barium is introduced by mouth or by rectum. After oral administration the haustrations of the colon are usually conspicuous, whereas if the colon is distended by a barium enema these tend to be very shallow. Little significance can be attached to the



ulcerative colitis (described below) by the fact that the sharp outline of the intestinal lumen is preserved, and by the persistence of haustrations. It must be remembered, however, that the latter are normally less prominent in the descending colon and sigmoid.

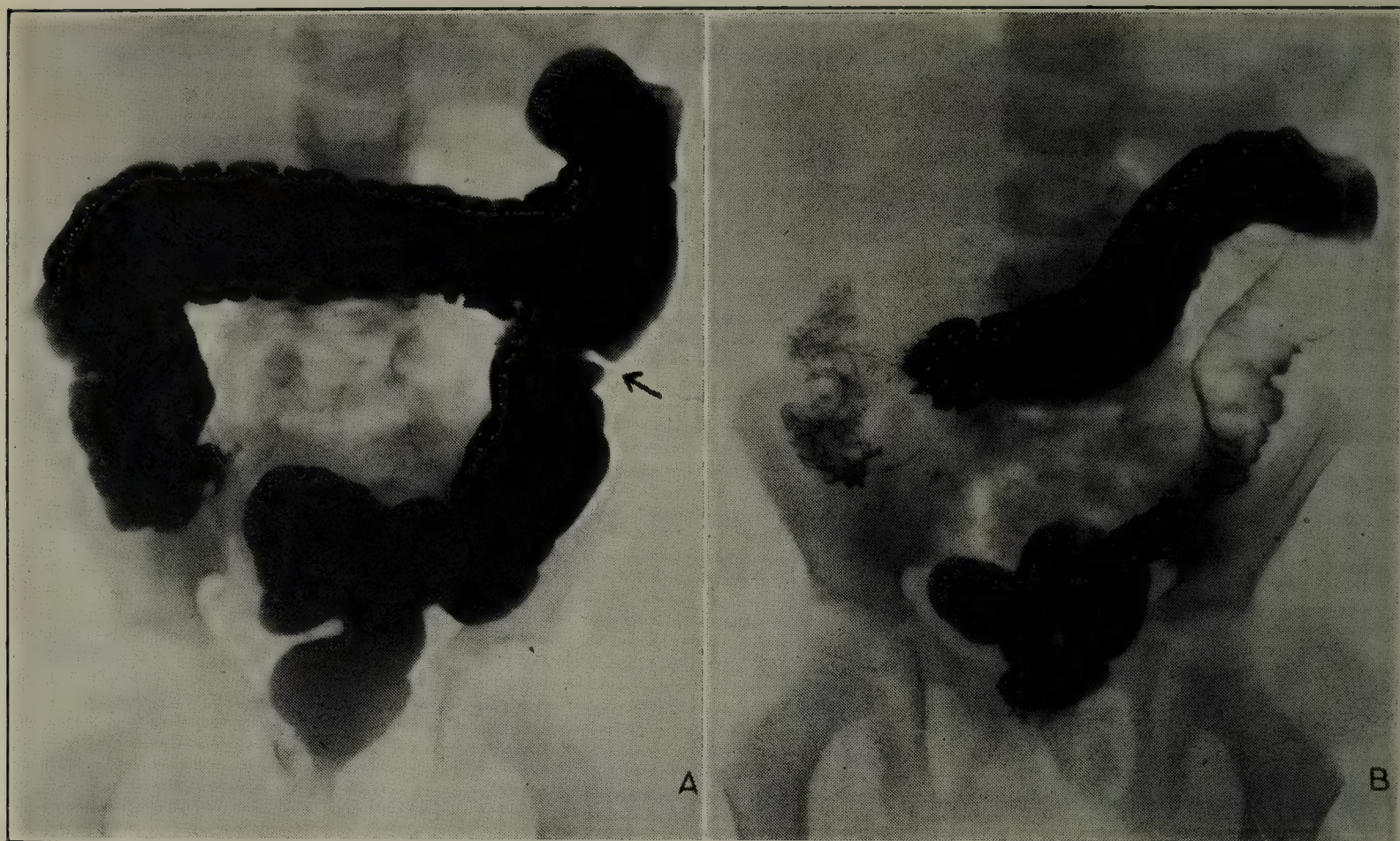


FIG. 39.—SPASTIC COLITIS.

This illustrates the value of a second examination immediately following the discharge of the barium enema in doubtful cases. In A, taken after the introduction of the barium, a small area of spasm (marked by the arrow) is present but not conspicuous. B, taken after the evacuation of the barium, indicates definite retention of the barium above this point and a colon almost completely free from barium at the region in question.

The response to atropine in full doses is a characteristic feature of this condition. Diets with residue should be avoided. Relief of symptoms may be most dramatic, and in fact the therapeutic test of application of these measures plays a considerable part in establishing the diagnosis. The neurotic factor often calls for a study of the home environment. It may be months or years before therapeutic measures may with impunity be relaxed.

**Chronic Ulcerative Colitis.**—This group of cases forms a definite clinical entity, although the etiology is not well understood. Particular organisms have been incriminated by different observers, the most recent being a bacillus described by Bergen, but none has met with general acceptance and it seems quite possible that the cause of chronic ulcerative colitis is not always the same. Some of the cases give a history of typical dysentery at the onset, but amebae or dysentery bacilli cannot be recovered in the chronic stage and do not appear to be responsible for the continuation of the symptoms. We have recently seen one case which could be attributed to the abuse of purgatives.

occurrence of deep haustrations in the former case unless they are sharply localized, whereas the presence of deep haustrations after an enema should always attract attention; this may be due to psychic disturbances (as explained above) or to an idiopathic spastic colon.



Persistent or recurring diarrhea, generally of mild degree, is the usual complaint, and the stools are accompanied by considerable quantities of mucus, often being streaked with blood. At other times there are periods of constipation, with the clinical evidences of spastic colitis just described. Most patients have a poor appetite, are listless, and fail to gain and grow normally. There may be mild pyrexia. Abdominal pain is sometimes conspicuous, and we know of several instances in which it led to laparotomy. Rectal tenesmus is a frequent complaint. Sigmoidoscopy may reveal thickening of the mucous membrane of the large bowel, with congestion and edema; ulcers are occasionally seen. The x-ray picture resembles that described under spastic colon, but with two distinct differences: (1) areas of spasm remain localized in repeated examinations instead of shifting from place to place and (2) there is a tendency toward disappearance of the haustrations. These may be completely obliterated in advanced cases, giving the picture of the "lead-pipe" colon. In these extreme cases the colon loses its elasticity; spasm is no longer a prominent feature and introduction of enemata is easily accomplished. The outline of the ulcerated colon has a typical frayed appearance, and characteristic residua may be seen after evacuation. At times the differentiation from polyposis may be difficult.

The treatment outlined for spastic colitis often brings symptomatic relief, even in patients not troubled by constipation. The rectal instillation of 2 to 3 ounces of olive oil at night may allay local symptoms, but in general topical applications and irrigations of all sorts are to be discouraged. The response to treatment is usually slow, and may be deferred for months, but even in advanced cases complete recovery may eventually occur. The nutrition of these children is often a matter of great concern and the presence of anemia should by no means be overlooked in the treatment. A few of the most severe cases will require ileostomy or appendicostomy to secure rest for the colon, but in most instances resort to surgery is unnecessary. The prognosis in children is distinctly better than in adults.

## HYPERTROPHY AND DILATATION OF THE COLON

Hirschsprung's disease (megacolon) is characterized by a great increase in the diameter of the colon and in the thickness of its wall. It was originally believed to be an idiopathic condition for which no sufficient anatomical cause could be found. Hence it has been known as congenital or "idiopathic" dilatation of the colon. Within recent years, however, it has become increasingly clear that in the majority of cases there is an obstruction to the passage of the intestinal contents through the large intestine, although when the intestines are removed and laid open, no evidence of obstruction may be found. The dilatation and hypertrophy are greatest in the sigmoid (Fig. 40), and in about one-third of the cases this alone is affected. In the majority of instances, however, all of the colon is involved; very rarely only the colon above the beginning of the sigmoid is affected. The degree which the dilatation and hypertrophy may reach is enormous. The colon may fill the greater part of the much-dilated abdominal cavity. There may be pressure upon, with a certain amount of atrophy of, the rest of the abdominal contents and the capacity of the thorax may even be encroached upon, the diaphragm being displaced upward to a marked extent. The inspissated contents of the colon may be many pounds in weight. The hypertrophy is chiefly due to an increase in the circular muscular



fibers of the affected portion of the large intestine. The mucous membrane may be normal or there may be large and oftentimes deep ulcers, which usually do not extend beyond the muscular coat but may involve this and even lead to perforation of the intestines with the consequent lesions of peritonitis.

It is now apparent that different causes may give rise to this condition; on this account many writers prefer to designate it as *Hirschsprung's syndrome*. In

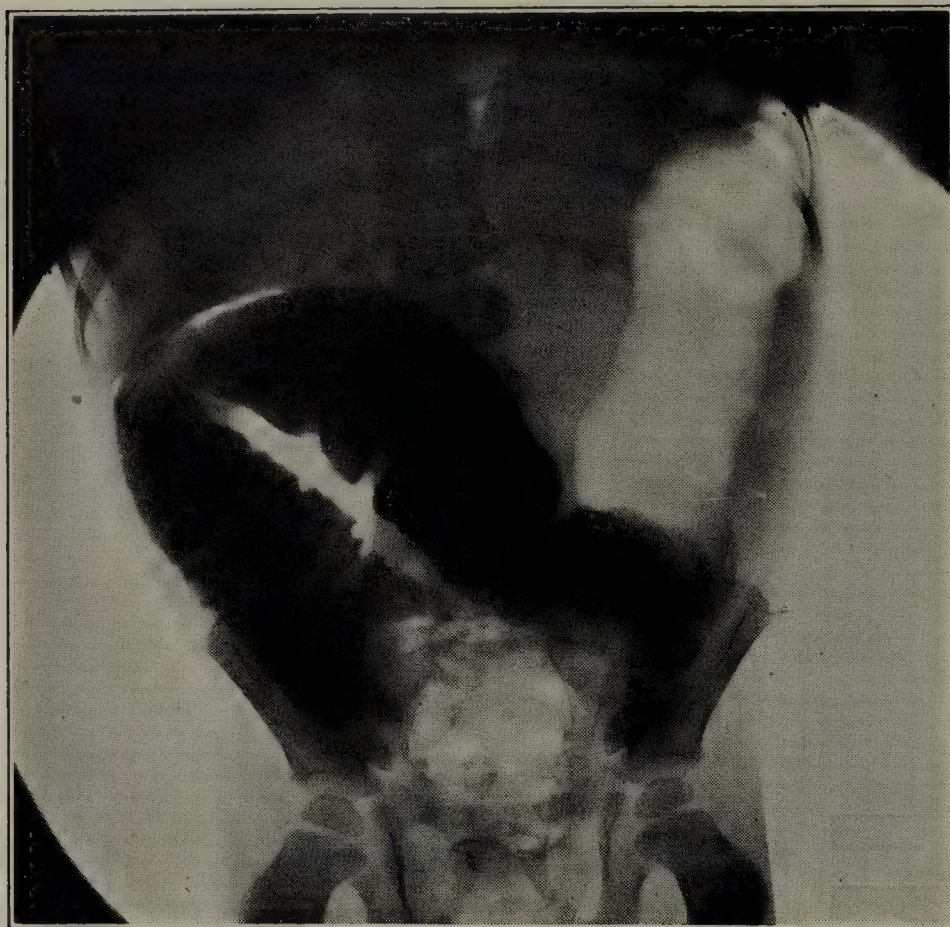


FIG. 40.—HIRSCHSPRUNG'S DISEASE.

Marked dilatation of the colon, especially of the sigmoid flexure, after bismuth injection.

many instances it appears to be the result of an abnormally long sigmoid and mesosigmoid which allows the lower portion of the sigmoid flexure to fall forward and downward, thus producing an angulation at its junction with the rectum. With the formation of this angle, the tendency is for the obstruction to increase and as the result of the effort of the portion of the large intestine proximal to it to overcome this obstruction, hypertrophy and dilatation take place. In other instances the fault seems to be an autonomic imbalance, which results in a loss of tone of part or the whole of the large intestine. A small proportion of these cases can be attributed to congenital anomalies. There may be great hypertrophy of the circular muscle in the neighborhood of the rectosigmoid junction, giving rise to the so-called "third sphincter." Diaphragms in this region have been described. Behring and Klercker described a case in which an incomplete membranous obstruction at this point gave rise to the Hirschsprung syndrome. The child did fairly well until a swallowed button became impacted upon this diaphragm, causing complete obstruction and death.

Though in some of the milder forms of the condition the symptoms may be delayed, they are usually seen in the first months of life. The characteristic symptoms are two: enlargement of the abdomen and obstinate constipation. The abdominal enlargement develops gradually and may become very great even in infancy. In marked cases the abdomen may be almost spherical. The greatest circumference is usually just above the navel. The distention is chiefly due to gas, although there may be a sufficient accumulation of fecal material to cause circumscribed dulness and marked resistance over the colon. Even shifting dulness is sometimes found.

The constipation does not differ at first from that due to other conditions, but it persists in spite of all treatment. Later, days, even weeks, may pass by without an evacuation from the bowels. The feces are then usually dry, dark brown or



greenish and very foul. Occasionally mucus and blood are passed, and in the late stages of the disease there may even be diarrhea, the result of ulceration. Marked peristaltic waves are almost always seen; they are usually in the lower part of the abdomen and on the right as well as on the left side. Pressure upon the abdomen is seldom painful, and then only to a slight extent unless some complication such as peritonitis is present. By rectal examination an obstruction to the finger is sometimes encountered. It is frequently found that a large quantity of water may be injected, which is expelled only after a considerable length of time. The urine is usually normal.

Attacks of vomiting from time to time are not unusual, but in general the digestion is good. In a number of cases spontaneous recovery occurs. These are usually cases of the milder type; and recovery is favored by the growth of the body, since the colon, fixed as it is below and attached above, tends to straighten itself out as the abdomen increases in length. In most of the severe cases the condition becomes gradually worse, the nutrition fails, there may be attacks of diarrhea with fever, or death may be due to some intercurrent infection, frequently of the lungs. Perforative peritonitis is an occasional fatal complication. In other cases, with careful feeding where constant pains are taken to empty the colon regularly, the child may be kept moderately free from discomfort, may enjoy a fair degree of health and may reach normal growth and development in spite of the existence of a greatly enlarged colon.

Borderline cases are seen in which the large intestine is moderately dilated, and in which constipation, though troublesome, can be controlled by diet and lubricants without resort to enemata. Many children appear to outgrow this condition at puberty, if not before. It is questionable whether such cases should be classed as examples of Hirschsprung's disease, but the difference appears to be only one of degree.

The two conditions most likely to be confounded with Hirschsprung's disease are tuberculous peritonitis and chronic intestinal indigestion (celiac disease). The latter is much more common than Hirschsprung's disease. It occurs frequently as a sequel of some frank intestinal disease, usually in the second or third year. Attacks of diarrhea in most cases alternate with constipation which is never so great as in Hirschsprung's disease; nor is the distention, as shown by the x-ray, so extreme. Marked deep waves of intestinal peristalsis are not present. Celiac disease is seldom seen at the early age at which Hirschsprung's disease is often found and the general condition of the child is always bad, while with Hirschsprung's disease the general health may be excellent for a long time.

Tuberculous peritonitis is characterized by a later onset, by the presence, oftentimes, of fluid in the abdominal cavity and of abdominal tumors, by evidence of tuberculosis elsewhere and by the presence of a positive tuberculin reaction. Compared with the frequency of these two diseases, Hirschsprung's disease is a very rare condition.

Palliative treatment should always be attempted by means of diet, liquid petrolatum and resort to enemata at intervals sufficiently frequent to prevent serious fecal impaction. If under these conditions distention increases, the general health may suffer. In cases in which there is kinking of the lower bowel, a vicious circle



may be established; with progressive dilatation the angulation is increased and the obstruction more difficult to overcome. Surgical procedures directed at the bowel itself are rarely successful. The most encouraging innovation in therapy has been contributed by Wade and Royle, based on the view that autonomic imbalance is at the root of the disturbance. In a number of patients striking and apparently permanent relief has followed resection of the lumbar sympathetic ganglia and the regional sympathetic rami. At the same time, it must be admitted that success with these measures has not been uniform. Scott and Morton advocate spinal anesthesia as a pre-operative test of the probable efficacy of ganglion resection. Under the influence of the spinal anesthetic some of these cases show prompt and vigorous contractions of the bowel; there may be normal expulsion of a stool within a few minutes. We have seen one such case which was markedly benefited by subsequent lumbar sympathectomy. Several weeks may be required after the operation before normal defecation is established.

### INTUSSUSCEPTION

Intussusception consists in the invagination of one portion of the intestine into another. It occurs most frequently in infancy, being at this age the most common cause of acute intestinal obstruction. The accident is not a common one, but the life of the patient generally depends upon its prompt recognition.

**Varieties.**—Usually the upper part of the intestine is invaginated into the lower, although the reverse is occasionally seen. Intussusceptions may occur at any point in the intestinal tract. Those of the small intestine are called *enteric*; those of the colon, *colic*; and those occurring at the ileocecal valve, *ileocecal*. Of 90 cases under ten years of age, in which the variety was determined by autopsy or operation, 75 were ileocecal, 9 colic, and 6 enteric. Several varieties of ileocecal intussusception are seen. The process may begin at the valve itself, with invagination of the colon. Not infrequently a double intussusception is found; the process begins in the lower ileum; the advancing tumor, when it reaches the ileocecal valve, cannot be passed and a second intussusception forms on top of the first at this point. Cases in which an intussusception of the ileum passes through the valve, but without invagination of the colon, are sometimes classed separately as an *ileocolic variety*.

*Intussusceptions of the dying*, as they have been called, are frequently met with in autopsies made upon infants; seldom in older children. They are descending, enteric, easily reducible, and multiple—usually from eight to twelve invaginations are present. They are more frequently in the jejunum than in the ileum. They usually involve but a few inches of the intestine, and are probably produced in the death agony. Such intussusceptions are of no clinical importance.

**Etiology.**—Of 358 collected cases in children under ten years, three-fourths occurred in the first two years of life; one-half of them between the ages of four and nine months. The youngest child with intussusception who has come under our personal observation was an infant of five weeks. In this child the symptoms came on about twelve hours after an operation for hypertrophic stenosis of the pylorus.



The condition occurs twice as frequently in males, a fact for which there is no explanation. The exciting causes of an attack are extremely obscure. The great majority of cases occur in children who are apparently in perfect health. Some previous intestinal disorder is present in a small proportion of the cases. Breast-fed infants are fully as liable to develop intussusception as those who are artificially fed.

**Pathology.**—Nothnagel's animal experiments have shown that intussusceptions are formed by the irregular action of the muscular walls of the intestine. They can be produced or released at will by varying the application of the electrical current. In the artificial intussusception there is first a contraction of a certain part of the intestine, and if this ceases abruptly the normal gut below this point turns upward and folds over upon the contracted portion, thus forming a minute intussusception (Fig. 41 A). When once begun, the intussusception increases solely at the expense of the external layer (Fig.



FIG. 41A.—MECHANISM OF INTUSSUSCEPTION.

41 B). Thus, while the apex of the tumor D remains unchanged, the part of the sheath at A passes to B and then to C, so that the lower part of the intestine is drawn over the upper, rather than the upper crowded into the lower.

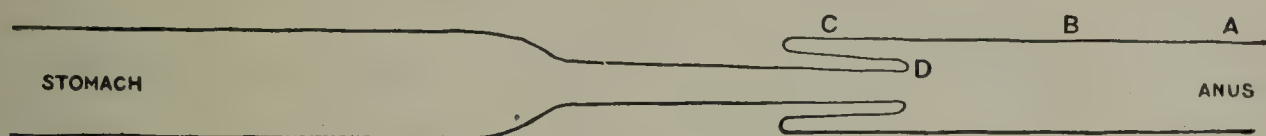


FIG. 41B.—MECHANISM OF INTUSSUSCEPTION.

There can be little doubt that pathological intussusceptions are produced in the same way. As the invagination takes place, the mesentery is drawn in with the bowel, and always lies between the sheath and the inner layer. To allow intussusception to occur, the mesentery must be unduly long, stretched, or lacerated. Its attachment to the spine causes the intussusception to describe an arc of a circle, the concavity of which is always toward the spine. It also causes a puckering of the tumor. Invagination does not necessarily produce either obstruction or strangulation, but usually both are present, and are the chief causes of the symptoms. Traction upon the mesentery leads to obstruction in its vessels, causing congestion, edema, hemorrhage, and even gangrene. Obstruction is chiefly due to swelling. It may be due to dragging of the mesentery, which brings the apex of the tumor against the side of the gut, or to bending of the intussusception. Intussusception is usually of all the coats of the intestine. We have, however, seen one, the exact nature of which was determined by operation, in which only the mucosa and submucosa were involved. The invagination was at the ileocecal valve. The symptoms were characteristic except for the absence of tumor. Sometimes the outer layer is not merely puckered but actually folded on itself to produce a double intussusception. Even triple intussusceptions have been observed.

The great cause of irreducibility in the first two or three days is swelling from edema. We have several times seen at autopsy or operation an intussusception



easily reduced, except the last 2 or 3 inches of the cecum or ileum, which was swollen to the thickness of from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch. Adhesions may prevent reduction, but rarely before the third day; they are often absent as late as the sixth or seventh day. They are usually between the internal and middle layers of the intussusceptum, and are due to local peritonitis. In chronic cases, however, they may form the principal obstacle to reduction.

Gangrene and sloughing of the gangrenous portion of the intestine occur much more often in acute than in chronic cases. Portions of intestine may then be passed *per anum*. This is very rare in infants. Toward the end of the second week is the time when the separation of the sloughs is to be looked for. The amount of intestine discharged varies from a few inches to several feet. In acute cases the intestine usually comes away in one large mass. In chronic cases shreds of intestine may be discharged for several weeks.

**Symptoms.**—The clinical picture of a case of acute intussusception is a striking one, and the symptoms are so uniform that, once seen, it can scarcely be overlooked a second time. The patient, usually between six and twelve months of age and well nourished, is taken suddenly ill with severe pain and vomiting; the pain recurs paroxysmally every few minutes; the vomiting is first of the contents of the stomach—afterward the vomited matters contain bile. There may be one or two loose fecal stools, then only blood or blood and mucus are passed without any admixture of feces. There is at first restlessness, then great prostration and even collapse—pallor, flaccidity, cold extremities, feeble pulse, with a normal or sub-normal temperature. The abdomen is relaxed; a mass is usually palpable in the epigastrium or the left iliac fossa, or it may be felt by rectum. In some cases it may be noticed that there is absence of intestinal gurgling on palpation of the right lower quadrant. The condition grows rapidly worse. The vomiting and pain continue; the abdomen becomes tympanitic. Signs of dehydration appear quickly; there is a steady increase in the prostration, and toward the end a rapidly rising temperature which may reach  $105^{\circ}$  or  $106^{\circ}$  F. before death occurs from collapse. If the symptoms continue longer the signs of peritonitis are added.

**Onset.**—By far the most frequent symptoms of onset are paroxysmal pain and vomiting. In a smaller number of cases the initial symptom is diarrhea or a discharge of blood and mucus.

**Pain.**—This is rarely continuous, but is intermittent, recurring in paroxysms like those of ordinary colic, but of great severity. The child sometimes shrieks so as to be heard all over the house. Pain is a prominent symptom in over three-fourths of the cases, and is very rarely absent. It is generally more marked for the first two days, but may continue throughout the attack.

**Vomiting** is more marked at the onset, but may continue throughout the attack. It is present in fully four-fifths of all cases and is often projectile. If food is given, vomiting often occurs as soon as it reaches the stomach. Stercoraceous vomiting is not uncommon in older children, but is seldom seen in infancy. It is rarely present before the third or fourth day. Although a bad sign, it is not by any means a fatal one, as nearly one-half the cases in which it has been noted have recovered; it is to be regarded as indicating complete intestinal obstruction rather than strangulation.



*Tumor.*—This is one of the most important symptoms for diagnosis because of its frequency and its peculiar character. It is present early in the disease, often in a few hours after the initial symptoms. It can be made out before the abdomen is opened in fully nine-tenths of the cases; although in a considerable number examination under anesthesia is necessary. The tumor is usually along the line of the colon, but may be found almost anywhere in the abdomen. In nearly half the cases it can be felt by rectum. In some it protrudes from the anus. Even when the invagination begins at the ileocecal valve it may reach the rectum in a surprisingly short time. In one of our cases it was felt in the rectum in less than twelve hours from the onset. The usual description, "sausage-shaped," is accurate when the invagination is large, the tumor then being from 4 to 6 inches long and about  $1\frac{1}{2}$  inches in diameter. It is often curved.

During manipulation, or during an attack of pain, the tumor may become more prominent and may be distinctly erectile. By rectal examination the palpable mass closely resembles the os uteri, the central opening being the apex of the intussusception. The examining finger is usually covered with bloody mucus, whether or not a tumor can be palpated. When protruding from the body, the tumor is rarely more than 2 inches long. It is usually of a deep purplish color, and may be gangrenous. It has been mistaken for prolapsus ani, polyp, and even hemorrhoids.

*Condition of the Bowels.*—Bloody stools are almost a constant symptom. The blood usually appears within six hours of the onset of colic; rarely is it delayed as long as twenty-four hours. This symptom was absent in only 10 per cent of Monrad's cases. Normal or diarrheal movements may be expelled promptly after the onset of colic; subsequently only blood and mucus are passed, with no traces of feces and with no fecal odor. The amount of blood varies from a quantity sufficient to stain the mucus ("currant jelly stool") to an ounce of semifluid blood ("prune juice stool"). Discharges of mucus and blood frequently follow attacks of severe colicky pain, and may occur several times in an hour. They may continue, or after a day or two they may be succeeded by absolute stoppage. Diarrhea is rarely present in the intussusceptions of children, particularly in infants. It belongs generally to chronic cases.

Tenesmus is very common if the tumor is rectal. Relaxation of the sphincter is met with in a considerable proportion of the cases when the tumor is in the sigmoid flexure or rectum.

During the first twenty-four or forty-eight hours the abdominal walls are soft and relaxed, and may even be retracted. Usually there is then little resistance to abdominal palpation. After the second or third day there is usually tympanites; but this does not necessarily mean that peritonitis exists. Localized tenderness is a symptom of some importance when a tumor is absent. Scanty urine is common, but of no special value in showing the seat of obstruction.

**Chronic Intussusception.**—In these cases neither are the symptoms of onset so acute nor the subsequent manifestations so dramatic. The mechanism of development of the intussusception is the same as in the acute cases, but obstruction of the lumen is incomplete and the changes in the bowel itself from vasoconstriction, congestion, and edema are less pronounced. The onset is usually with vague,



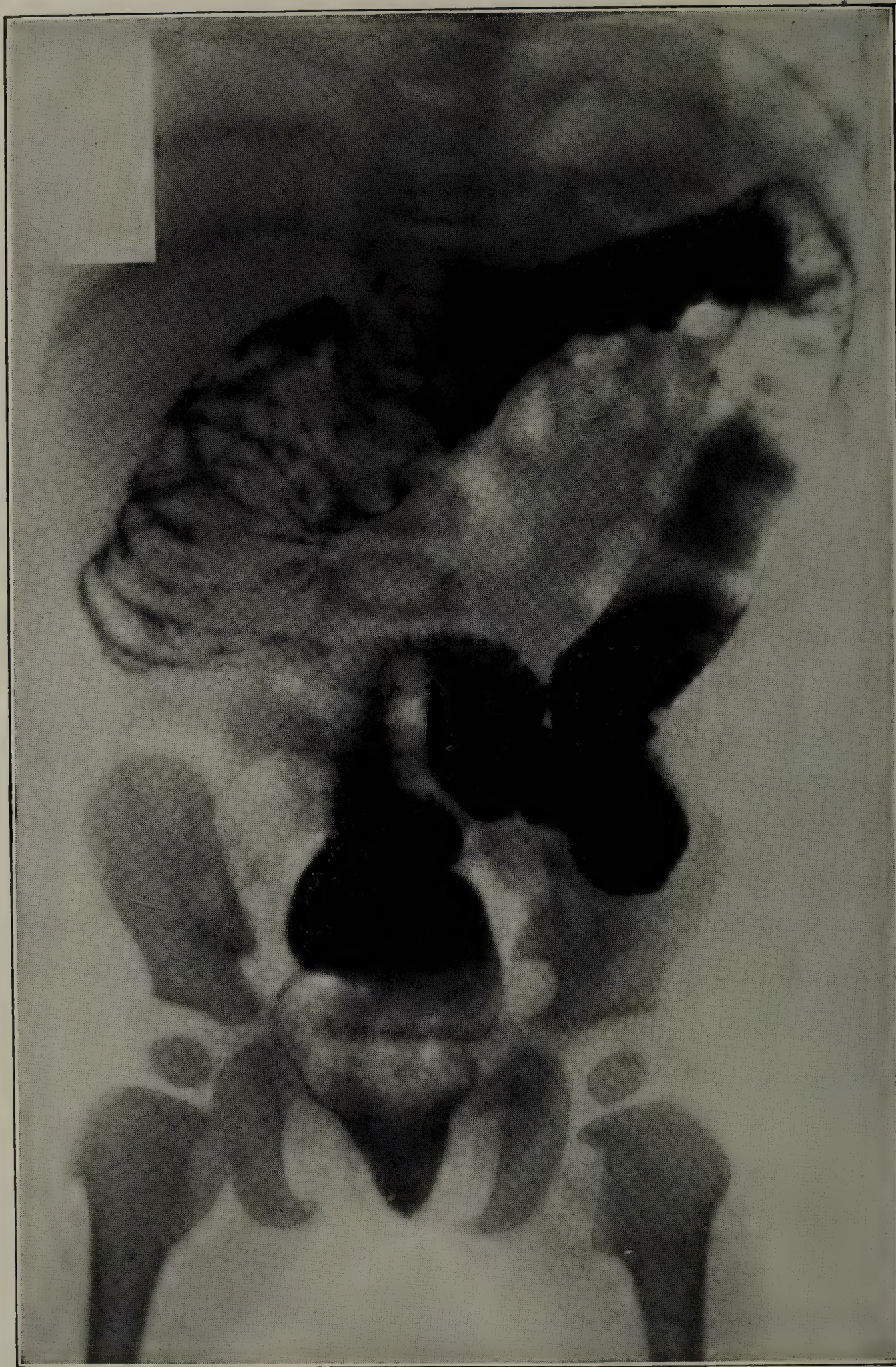


FIG. 42.—ROENTGENOGRAM AFTER OPAQUE ENEMA IN A CASE OF CHRONIC ILEOCECAL INTUSSUSCEPTION IN AN INFANT ELEVEN MONTHS OLD.

At operation the intussusception was irreducible and resection of the distal ileum, cecum and ascending colon, followed by axial anastomosis of the ileum and transverse colon, was carried out. The child recovered after a fairly smooth convalescence (Bolling).



indefinite intestinal symptoms. Pain, vomiting and bloody discharges are often wanting. There is often only progressive loss of weight, sometimes with constipation and colic, sometimes with diarrhea. Only the presence of the tumor leads to the recognition of the condition, though we have seen an instance in which there was marked bleeding.

**Course, Duration, and Termination.**—Of 198 cases under ten years, 155 were classed as acute, lasting less than seven days; 33 lasted from one to four weeks, and 10 lasted over four weeks. Nearly all the cases occurring in infancy are acute.

That spontaneous reduction of intussusception sometimes occurs there can be no doubt. In one of our own cases, in an infant of eleven months in whom typical symptoms—sudden onset, severe paroxysmal pain, persistent vomiting, bloody and mucous stools—had lasted for forty-eight hours, when the abdomen was opened after the child had taken a five-mile ride in an automobile the ileum in the ileocecal region was found for a short distance edematous, congested, in fact, showing exactly the appearance which is usually seen after an intussusception has been reduced at operation. The vomiting, pain and bloody stools ceased, although nothing was done. Another case has come to our notice in which typical symptoms, including an abdominal tumor, were present and preparations were made for operation, when the child suddenly passed a fecal stool, the tumor disappeared and the other symptoms also.

It is quite possible that some cases of severe colic are really cases of slight intussusception which undergo spontaneous reduction. There are seen in both conditions the tendency to vomit, the paroxysmal pain, the constitutional depression, and often the sudden cessation of the symptoms, but a positive diagnosis of invagination with such symptoms is impossible. Intussusception may be cured spontaneously by sloughing of the invaginated part, the continuity of the intestine being preserved by adhesions. Such a result is rare at all ages, and is almost never seen in infancy.

The most frequent cause of death in acute cases is shock. Peritonitis is not found at autopsy or operation so often as might be expected. In 58 autopsies, it was seen but 20 times, and in 7 of these it was limited to the intussusceptum. In but 7 cases was there perforation.

**Diagnosis.**—This usually presents little difficulty in acute cases provided the physician has the condition in mind. The great majority of such cases present nearly all the classical symptoms, *viz.*, sudden onset, recurring colicky pains, frequent vomiting, bloody and mucous stools without fecal matter, general prostration or collapse, and low temperature. The records show that the most common error is to regard the case for the first few days as one of gastro-enteritis or dysentery, the physician's attention being engrossed by the vomiting and bloody stools. Given the other usual symptoms, the presence of the characteristic tumor is conclusive evidence of intussusception. In any case of doubt the patient should be examined under anesthesia. In any case of acute intestinal obstruction in infants, intussusception should first be considered. We once saw in a young infant with strangulated hernia nearly every symptom of intussusception except the abdominal tumor; in another infant with an inflamed Meckel's diverticulum there was vomit-



ing, bloody and mucous stools and an elongated tumor in the hypogastric region. In acute cases the diagnosis can be correctly established without the use of the x-ray, which only subjects the patient to an unwarranted delay. In chronic cases, on the other hand, x-ray or fluoroscopy of the colon may be helpful in demonstrating the site of obstruction. In both acute and chronic cases of intussusception rectal examination is most important for diagnosis, and often settles the question at once.

**Prognosis.**—The mortality in untreated cases is close to 100 per cent. Although spontaneous reduction does occur, and recoveries have been reported following sloughing away of the intussusciens with auto-anastomosis of the intestine, such fortunate events are not to be expected. The prognosis depends not so much upon the age of the patient or the variety of intussusception as upon early treatment. The mortality is little more than 10 per cent in cases operated on within twenty-four hours; most of these cases can be reduced without difficulty. The longer the delay, the more difficult does reduction become; an increasing number of cases are irreducible or gangrenous and require resection. Moreover, these late cases are likely to exhibit pronounced toxemia and shock. If the condition has been allowed to persist for three days or more the mortality is between 50 and 75 per cent. Delay is less serious in the cases with incomplete obstruction, but even these should be operated on at the earliest possible moment. Recurrences are rare. We have, however, observed a patient who was successfully operated on for intussusception at the age of eleven months, at twenty-seven months, and again at six years.

**Treatment.**—The diagnosis of acute intussusception once made, laparotomy should be performed without an hour's unnecessary delay. Monrad has been able by his method of traction under anesthesia to reduce many of these cases without operation. Although his statistics are as favorable as any, this procedure is not likely to be as successful in unskilled hands as direct resort to surgery. Operation should be looked on as a measure which, if employed reasonably early, offers a good prospect of success. If the intussusception can be reduced, the bowel is apt to recover, no matter how seriously damaged it may appear at the time of operation. In the presence of frank gangrene, however, or an irreducible mass, the involved segment must be resected.

The condition of the patient as a whole must not be lost sight of, particularly his fluid balance. The amount of blood lost in the stools is hardly ever great enough to require transfusion. In the postoperative period no cathartic should be used which might call forth active peristalsis.

## APPENDICITIS

Appendicitis is met with at all ages, and is not especially a disease of children. When it attacks those over ten or twelve years of age it does not differ essentially from the types observed in adults. All that will be attempted in this chapter will be a consideration of the peculiarities of the disease as it is ordinarily seen in children, particularly in young children. For a fuller discussion of the disease as a whole, the reader is referred to works on general medicine and surgery.



**Etiology.**—Of 1000 cases of appendicitis personally observed by McCosh, 85 occurred in children between the ages of ten and fifteen years; 51 between the ages of five and ten years, and only 17 under five years; of these but 4 were under two years. Churchman's figures from the Johns Hopkins Hospital, in a total of 1223 cases, give only 9 cases under five years, and 50 between five and ten years. In infancy and early childhood appendicitis is, therefore, a relatively rare disease. The youngest case that has come under our observation was in an infant of ten weeks. Operation was performed and recovery followed. The predominance of the male sex holds true even in childhood. Of 101 cases under fifteen years, 72 were in males and 29 were in females.

Regarding the immediate cause of an attack but little is yet definitely known. Occasionally a foreign body, a fecal concretion, or intestinal parasites are discovered in the appendix; there is reason for believing that these may at times be the exciting factor. The bacteria most frequently found in abscesses from appendicitis are streptococci, usually associated with colon bacilli.

**Pathology.**—All the common varieties of acute appendicitis—the catarrhal, suppurative, and gangrenous—are met with in children; and, much less frequently, the chronic form. The lesions present few peculiarities in early life except that, owing possibly to the relation of the appendix to the omentum, perforative inflammations are less likely to be circumscribed by inflammatory products and much more likely to result in a general peritonitis than in adults. Whether or not this be the correct explanation, it is certainly true that general peritonitis is a much more common sequel in children than in adults. Another point of some importance is the fact that in early life the appendix is rather more frequently found out of the usual position. The inflammation excited by worms in the appendix is usually a superficial one; when they are the cause, perforation and abscess formation are almost unknown.

**Symptoms.**—In many of the cases the familiar symptoms of appendicitis—vomiting, localized pain and tenderness, muscular rigidity, abdominal distention, and fever—are all present, and the diagnosis is easy. But in perhaps the larger number, the disease is irregular in its onset, insidious in its course, and presents at times great difficulties in diagnosis. This is particularly true of appendicitis in children under five years. Vomiting and constipation are very common, but pain is invariably present and is a symptom of the utmost importance. At the beginning of an attack, just as with an adult, the pain may be referred to some other part of the abdomen, now to one side and now to the other. Often the only evidences of its presence, especially in young children, are restlessness, frequent crying and inability to sleep. If the appendix is very long and dips down into the pelvis, or if localized collections of pus form around the bladder and rectum, there may be pain on urination or defecation, which in small children gives rise to screaming attacks at these times. Children with appendicitis are often reluctant to sit up, or if examined in the supine position will refuse to flex the thighs—particularly the right thigh—against resistance. Spasm of the flexors of the thigh may interfere with complete extension at the hip joint, and in subacute cases the lameness caused thereby has suggested tuberculosis of the hip.

Localized abdominal tenderness is even more difficult to detect and to interpret



than pain. Young children, especially if nervous and sensitive, shrink from any touch and the results of abdominal palpation may be most unreliable. In any child under three years of age, it is almost impossible to make out localized tenderness. The same is true of muscular rigidity. Tenderness and muscular rigidity are sometimes shown by the child's disinclination to move either the trunk or the lower extremities and by evidences of pain when he is moved.

Localized abscesses are found with children as with adults, but there is a tendency for them to form in other situations than the right iliac fossa. They may be on the left side of the abdomen, in the pelvis, or they may travel beneath or even above the liver. On account of the resistance of the child, palpation and detection of the abscess may be impossible without a general anesthetic. A rectal examination should not be omitted; it may reveal a mass or an area of tenderness. Constipation is usually present, but by no means so regularly as in adults. Diarrhea is not at all uncommon, and, when associated with vomiting, tends to divert attention from the appendix to an ordinary gastro-intestinal disturbance. Abdominal distention, when present, is of much importance, taken with other symptoms. Fever is rather more apt to be high than in adults. But there are many exceptions, and, on the whole, the temperature is a very untrustworthy guide to either diagnosis or prognosis. The leukocyte count is of much assistance in diagnosis, at least in suppurative forms of appendicitis. A leukocytosis of at least 10,000 to 20,000 is usually present, with a polymorphonuclear percentage of over 75; but many exceptions are met with, and it is not safe to exclude appendicitis because of the absence of this finding.

A certain number of cases begin with definite symptoms—pain, vomiting, fever, and constipation—and continue with slowly or rapidly advancing symptoms to increasing prostration, continued vomiting, constipation, rapid pulse, abdominal distention, rigidity, higher temperature, and death by general peritonitis at the end of five or seven days' illness. Others, with a similar onset, show a gradual abatement of all acute symptoms after a few days, and recovery at the end of ten days or two weeks, followed, perhaps, by another attack after a few months. These types are seen in children as in adults. But others are quite common. A child may be taken ill, sometimes abruptly, sometimes more gradually, with vomiting, which is repeated several times in a single day, afterward only occasionally. There is some pain; it is not very definite and not localized. The prostration is only moderate, the temperature not over 100° to 100.5° F. The examination shows little. Tenderness cannot be definitely made out; the child is irritable, fretful, wishes to be left alone, and resists all efforts at abdominal palpation. The bowels are constipated, or they may be at first loose and afterwards constipated. The child does not seem very sick. The attack is often regarded as an ordinary one of acute indigestion. But things do not improve as they ought. The pulse becomes more rapid, the prostration greater, and the child begins to look seriously ill, though the temperature has not risen. The abdominal distention is now considerable and tenderness undoubted. An operation is decided on, and there is found a gangrenous appendix and a diffuse general peritonitis. Sometimes the grave symptoms develop with great rapidity in the course of a few hours, when previous symptoms had all been mild; sometimes so insidiously that the transition is almost imperceptible.



**Prognosis.**—The prognosis in children under two years is not good, largely owing to difficulties in early diagnosis and late resort to operation; of 132 collected cases in infants and very young children the mortality was 38 per cent. But in those over seven years old the outlook is rather better than in adults. General peritonitis, it is generally agreed, occurs much oftener in children than in adults and is altogether the most frequent cause of death. If general peritonitis occurs, the chances of recovery after operation are, however, rather better with children than with adults.

**Diagnosis.**—The diagnostic symptoms of appendicitis are a sudden onset with vomiting, abdominal pain which at the start may be colicky and vague but which eventually becomes persistent and sharp, acute localized tenderness, and rigidity of any or all of the abdominal muscles. A mass may be palpable, particularly in cases seen a day or more after the onset. Constipation is more frequent than diarrhea, though the latter is not rare. There is almost invariably some elevation of temperature, but not often high fever.

Appendicitis may be confounded with colic, indigestion, and, in infants, with intussusception; in older children, with psoas abscess. Severe colic with fever in children over three years old should always be regarded with suspicion, especially if there is a polymorphonuclear leukocytosis. From acute indigestion the diagnosis of appendicitis is difficult at the onset, and it may be impossible for twenty-four hours. However, the pain of indigestion is rarely so severe, while the fever is often higher. The pain in appendicitis is not always localized, nor is the tumor always in the right iliac fossa. Cyclic vomiting may simulate recurring attacks due to a chronic appendicitis. It is distinguished by the history of the previous attacks, the greater frequency with which the vomiting occurs, its abrupt cessation after twenty-four to seventy-two hours, the sunken abdomen, and the absence of localized pain, tenderness, and rigidity. Acute or subacute suppuration in the right iliac fossa is almost invariably due to appendicitis.

Pneumonia may be confounded with appendicitis. There may be vomiting, severe localized pain and sometimes exquisite superficial tenderness with abdominal rigidity. The child with pneumonia usually appears sicker than one with appendicitis, the fever is higher and the leukocytosis more marked, *i.e.*, over 20,000. Physical signs in the chest and, in the absence of these, an x-ray plate may offer material assistance. The differential diagnosis between pneumonia and appendicitis may be very difficult, but is of great importance to the patient because of the harm that may be caused by application of the wrong therapy. Severe abdominal pain accompanying acute rheumatic fever may be confused with appendicitis. In one of our patients exploratory laparotomy revealed marked diffuse congestion of the peritoneum without definite evidence of pyogenic infection and with no particular abnormality of the appendix; signs of acute carditis developed a few days later. The symptoms at the onset of acute infection of the upper urinary tract sometimes resemble those of appendicitis; the finding of a large amount of pus in the urine may prevent unnecessary operative intervention. In many of the cases of so-called primary peritonitis caused by pneumococcus or streptococcus infection, and in the majority of those of ovarian cyst with twisted pedicle, appendicitis has been the preoperative diagnosis; but here the differential diagnosis without exploration is



virtually impossible, and one is scarcely justified in attempting it. The symptoms of appendicitis are often closely simulated in certain patients who at operation show merely a mesenteric lymphadenitis, with swelling and congestion of the glands about the appendix and cecum; sometimes these are found to be tuberculous. Whenever, in children over two years old, there are symptoms pointing to acute peritonitis, no matter what their combination or variety, appendicitis should always be suspected.

The chief difficulty in diagnosis is with infants and small children, because the disease runs a rapid course, but chiefly because it is often not considered as a possibility. There may be only vomiting, constipation, irritability, sleeplessness, and restlessness. The fever may not be high,  $100^{\circ}$  to  $100.5^{\circ}$  F., the prostration only moderate, the physical examination very unsatisfactory, and the leukocytosis not marked. Unless appendicitis is suspected, valuable time may be lost and the first symptoms to excite concern may be those of general peritonitis, which may develop in a few hours. Few cases in patients under five years of age come to operation before rupture of the appendix.

**Treatment.**—Absolute rest in bed cannot be too strongly insisted upon whenever appendicitis is suspected, no matter how mild the attack may appear. As a local application, the ice-bag is to be preferred. Opium should not be given, since it obscures the surgical signs; nor should cathartics, which may promote peristalsis and spread the infection. The colon may be emptied by the use of enemata.

Appendicitis is a surgical disease, and surgical advice should be sought early. In deciding as to the time of operative interference, it should be remembered that localization of the inflammation is less likely to occur with children than with older patients and that therefore the dangers of general peritonitis are much greater; that the progress of the disease is much less regular; that grave conditions are not revealed at once by grave symptoms; that the disease is an insidious one, and that to foretell the outcome even in the mildest cases is impossible. Taking all these things into account, we believe that immediate operation, once the diagnosis is made, is the course to be recommended in all cases of acute appendicitis in children. The younger the child the greater the urgency for operation.

### INTESTINAL PARASITES

Judging by published reports, intestinal worms are much more common in Europe than in most regions of this country. In more than 67,000 patients admitted to the dispensary of the Harriet Lane Home in Baltimore, positive evidence of worms was obtained in but 451 cases. Examination of the stools was not made routinely, but only when suggestive symptoms were present. Of the types identified there were 270 cases of *Oxyuris*, 107 of *Ascaris*, 70 of *Taenia*, 2 of *Uncinaria*, and 1 of *Trichuris trichiura*. In some patients there was multiple infestation, usually with round-worms and threadworms. The incidence of parasitic disease depends a good deal on geographical considerations, particularly in the case of hookworm. In private practice among the better classes, worms are certainly rare.

**Oxyuris Vermicularis—Pinworm—Threadworm.**—The *Oxyuris* resembles a short piece of white thread. The female is about one-third of an inch long, the



male about one-half that length, but is less frequently seen. The worm tapers toward the tail. The ova are of slightly irregular size, and are considerably smaller than those of the round-worm.

The *Oxyuris* inhabits the rectum, the cecum, and very frequently the appendix. These worms may be found also in the lower small intestine, the stomach, and even in the mouth. If present in the rectum they are usually discovered by separating the folds of the anus. The number of worms is usually large. The irritation to which they give rise causes a great production of mucus, and frequently leads to a chronic catarrh of the colon of considerable severity. The worms are embedded in the mucus; often they form with it small balls. According to Leuckart, they are incapable of multiplying *in situ*. Doubt has been thrown upon this view by the observations of Still. From the immature character and the large numbers of the worms found in the appendix (more than one hundred in one case), this writer believes that the appendix may be a breeding place. Ova may be absent, or may be passed in enormous numbers with the stools. They attach themselves to the folds of the skin, the hairs about the anus, and even to the genitals. The patient may, through lack of cleanliness of the parts, continually re-infect himself. After discharge from the body, the ova may be carried by flies and deposited upon fruits, vegetables, or in drinking water.

*Symptoms.*—The principal local symptom caused by the *Oxyuris* is itching of the anus or the genitals. This is caused by the migration of the worms from the bowel, and usually comes on about the same hour at night, generally soon after the patient has retired. It is sometimes so intense as to be almost intolerable. It leads to frequent micturition, to incontinence of urine, in the male to balanitis, and in the female to vaginitis or vulvitis, and in both, but especially in the latter, it may be the cause of masturbation. Owing to the catarrhal colitis which is excited, there is discharged from time to time a large quantity of mucus. Severe colicky pains are often associated. The irritation may lead to prolapsus ani. Nervous symptoms are not so frequently associated as with the other varieties of worms. The general health is sometimes undermined and there may be marked and progressive loss in weight.

*Treatment.*—This is usually spoken of as a very simple matter, and in recent cases, or where the number of worms is small, this is true; but where the number is large, and considerable catarrhal inflammation of the colon is present, it is often a matter of the greatest difficulty to rid the bowel of these parasites. Cases frequently resist treatment by injection for months or years, even though thoroughly used. The reason for this is, that only the lower colon is reached by injections while the worms may be chiefly in the cecum or even in the appendix and small intestine. While, therefore, injections are important and indeed invaluable, they cannot be relied upon exclusively. The most scrupulous attention to cleanliness is an absolute necessity as the first step in the treatment. It is well to bathe the parts about the anus after each stool, and even two or three times a day, with a mercury bichloride solution, 1:10,000. Itching is best controlled by the application of mercurial ointment to the folds of the anus at bedtime, thus effectually preventing the escape of the worms from the bowel. The local application of cold will sometimes have the same effect. The most efficient of the injections is probably a



solution of mercury bichloride. The colon should first be thoroughly cleansed by an injection of lukewarm water containing one teaspoonful of borax to the pint, in order to remove the mucus. When this has been discharged, half a pint of 1:10,000 bichloride of mercury solution should be injected high into the bowel through a catheter, and retained as long as possible. This should be repeated every second or third night. On other nights a simple saline injection may be employed. Infusions of quassia, asafetida, aloes, and garlic are also useful. Solutions of carbolic acid should never be employed.

When the worms are high in the colon, drugs by mouth must be combined with injections. The most efficient remedies are those recommended for round-worms. We have known one case, which resisted for over two years everything which had been tried, to be cured in two or three weeks by injections of a decoction of garlic, in connection with which garlic was given in liberal quantities by mouth.

**Ascaris Lumbricoides—Round-worm.**—This worm is usually found in the small intestine. It is exceedingly rare in infancy, but is usually seen between the third and tenth years. In over two thousand autopsies upon infants we have only twice found a round-worm in the intestine.

The round-worm bears some external resemblance to the ordinary earthworm; it is from 5 to 10 inches long, the female being longer than the male. It is of a light gray color with a slightly pinkish tint, cylindrical, and tapering toward the extremities. These worms rarely exist singly; usually from two to ten are present, but there may be hundreds. When very numerous they coil up and form large masses, which may cause intestinal obstruction and an abdominal tumor of considerable size.

The migration of these worms is curious, and in some instances truly remarkable. They frequently enter the stomach and are vomited. Occasionally one may appear in the nose. They have been known to pass through the eustachian tube into the middle ear and to appear in the external meatus. Entering the larynx they have produced fatal asphyxia. It is not very rare for them to enter the common bile duct and produce jaundice. They may even enter in great numbers the smaller bile ducts and produce hepatic abscesses. They have been found in the pancreatic duct, in the vermiform appendix, and in the splenic vein. It has long been known that they would perforate an intestine which was the seat of ulceration, but well-authenticated cases have been reported in which they have perforated both the stomach and intestine, setting up a fatal peritonitis. In cases of a persistent Meckel's diverticulum, worms have been discharged from an umbilical fistula. They have been found in umbilical abscesses. Considering, however, the frequency of round-worms, migrations are rare.

**Symptoms.**—The symptoms of round-worms are of the most indefinite kind; often there are none until the worm is discovered in the stools. It is then fair to assume that other worms are also present. The most frequent abdominal symptoms are colic, tympanites, and other symptoms of indigestion, loss of appetite and disturbed sleep. These symptoms are much more frequently due to other causes than to worms, but when all are present the existence of worms should be considered.

A great variety of nervous symptoms may be associated with intestinal worms.



They are more often seen with lumbricoids than with any of the other varieties. As in the case of the abdominal symptoms, however, intestinal worms are only one of the causes of nervous disturbances, and certainly not a frequent one. The blood generally shows eosinophilia, as in patients with tapeworm.

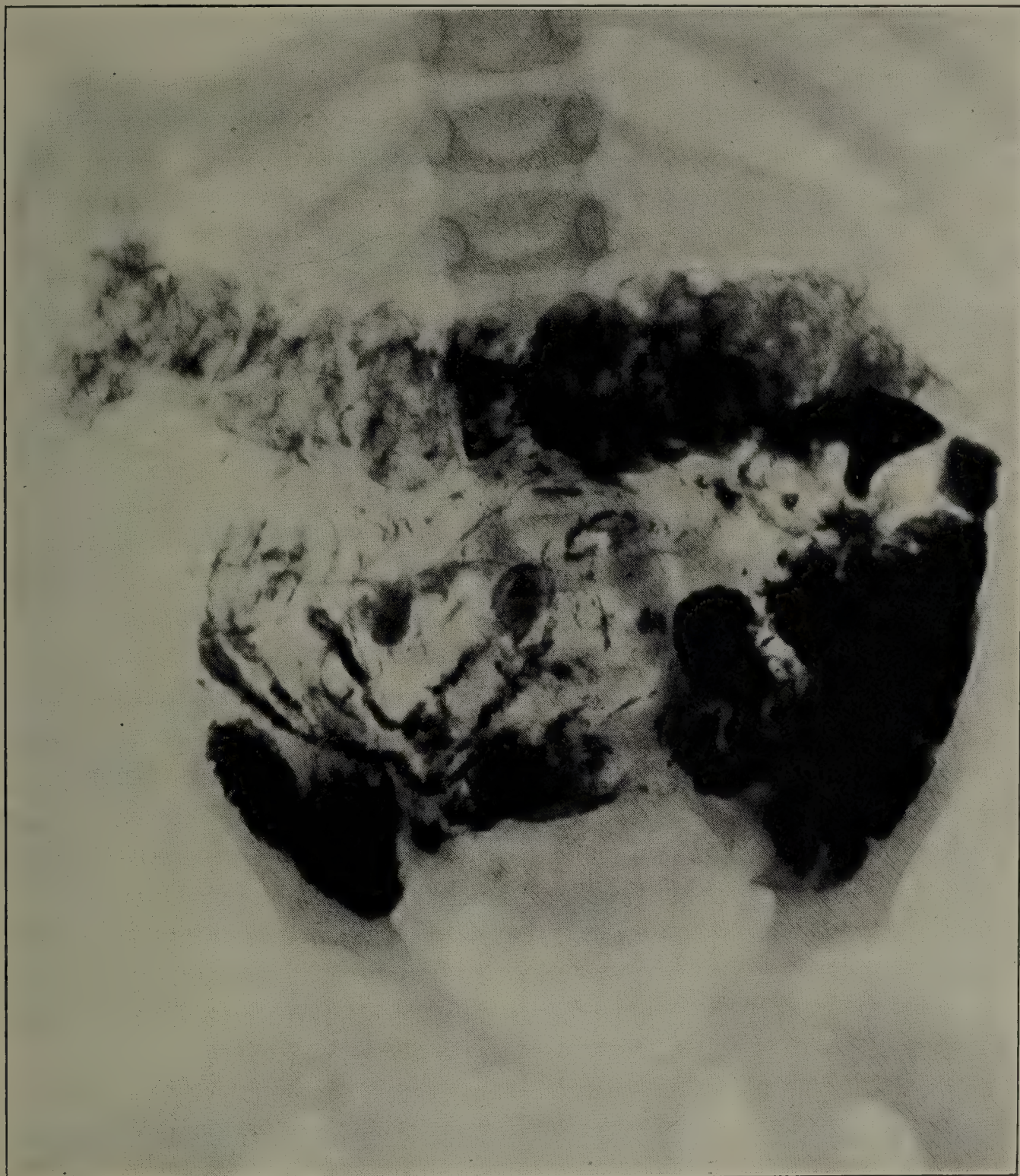


FIG. 43.—ROENTGENOGRAM IN ASCARIASIS, FOLLOWING BARIUM MEAL.

When round-worms are numerous there may be a severe degree of anemia and symptoms which are practically the same as those produced by hookworms. The only positive evidence of the existence of round-worms is the discharge of a worm from the body, or the discovery of the ova in the stools. When worms are present the ova may be found in great numbers. Absence of ova, however, does not mean that worms are not present, for males may remain.

The x-ray may be of diagnostic importance. With a barium meal, given after a fast, filling defects may first be seen owing to mechanical displacement; later, the barium ingested by the worms, and remaining in their alimentary tract after



the clearing of the patient's intestinal lumen by normal peristalsis, casts a characteristic shadow (Fig. 43).

*Treatment.*—The following routine has been found satisfactory: a twenty-four hour period of starvation should precede the administration of the vermifuge. This is given early in the morning and is followed some hours later by a saline cathartic; the patient is kept in bed for the day and given a light diet. Santonin is an effective vermifuge that has stood the test of time, but it may induce vomiting and toxic symptoms. Three grains may be given to a child of five years; it is administered in 1 grain doses at intervals of three hours. The drug may be mixed with powdered sugar. Oil of chenopodium is somewhat easier of administration and is quite as efficient. The dose is one-half drop for each year of the child's age up to ten years, given on lump sugar. Oil of chenopodium produces toxic manifestations in a small percentage of individuals who have an idiosyncrasy to it. The early symptoms are dizziness and headache; the patient may develop an intention tremor; in some instances collapse and coma with a fatal termination have ensued. The safest drug to use is apparently hexylresorcinol, which has recently been employed by Lamson with notable success in the treatment of these worms. The drug is given in the form of capsules or pills, which must not be chewed since they are irritating to the mouth; 0.5 gram may be given to a child of five years, followed by a cathartic twenty-four hours later. Aside from rare instances of dermatitis, toxic reactions following the use of this drug are unknown.

**Taenia Saginata—Beef Tapeworm.**—Infection results from eating raw or partially cooked beef containing cysticerci. For a full description of the worm and its life cycle one is referred to manuals of laboratory diagnosis or parasitology.

*Symptoms.*—The only positive evidence of tapeworm is the discharge of the segments, either singly or in groups, or the discovery of the eggs. In the great majority of cases there is no associated symptomatology. Conditions such as foul breath, disturbed sleep, grinding of the teeth at night, colicky attacks or other annoying sensations usually referred to the abdomen, inordinate or capricious appetite, diarrhea, and malnutrition, all of which are associated in the lay mind with tapeworm infestation, are far more apt to be due to other causes. An eosinophilia of from 4 to 10 per cent is frequently present.

*Treatment.*—Prophylaxis requires the cooking of meat to a sufficient degree to destroy the cysticerci. The list of drugs used for the expulsion of the worm is a long one; probably the most efficient is the oleoresin of male fern; it is, however, difficult to administer and it is very likely to provoke vomiting. It may be given in capsules containing  $\mathfrak{m}_x$  to  $\mathfrak{m}_{xx}$ , or in an emulsion made up with simple elixir and acacia, in which  $\mathfrak{m}_v$  to  $\mathfrak{m}_x$  are contained in one dram. For a child of four years at least one dram of the male fern should be given in the course of six to eight hours. Another excellent remedy is pelletierine tannate. The dose is 3 to 4 grains in capsule or in syrup of citric acid. The same routine for administration of the vermifuge should be followed as in the treatment of ascariasis. Other drugs useful for taenia are pumpkin seeds, which are given in powdered form, infusion of pomegranate root, and oil of chenopodium.

**Other Cestodes.**—*Taenia solium*, or pork tapeworm, while common enough in adults, is rare in children.



*Hymenolepis nana*, or dwarf tapeworm, has been found in various parts of this country. Infection is probably acquired by swallowing the ova themselves, since the cysticerci are not found in the muscles of any animal used for food.

*Dipylidium caninum*, *dibothriocephalus latus*, and *echinococcus granulosus* seldom invade children.

**Uncinaria Americana—Hookworm.**—This form is uncommon except in certain hookworm areas, notably in the mountainous regions of Kentucky, Tennessee, and the Carolinas. Infection usually takes place through the skin of the bare feet, more rarely that of the hands. It is possible to contract the disease by eating dirty fruit or vegetables contaminated by the developing larvae, but infection does not occur from swallowing the ova or young larvae. After entering the skin the larvae find their way into the circulation and thus reach the lungs. From the lungs they may migrate or be coughed up into the mouth and then swallowed. They are not acted upon by the gastro-intestinal secretions, and in the upper part of the small intestine they develop into mature worms. These may exist in the small intestine for years.

As the result of extensive investigations in regions infected by hookworm it has become clear that hookworm infection and hookworm disease are not the same thing. Infection with a few worms does not produce symptoms. Worms may remain in the intestines with impunity for a long time. As they do not multiply, no increase in the number will take place except as the result of repeated infections. It is only when the worms are very numerous that symptoms are likely to arise. For this reason children under eight years of age may harbor hookworms but usually are not in urgent need of treatment.

The symptoms in the milder cases are minor digestive disturbances, general malnutrition with moderate anemia and arrested growth. In the more severe cases the anemia is very marked, the hemoglobin often falling to 30 per cent or below. The leukocytes are normal in number or slightly increased, but the percentage of eosinophils is above the normal. In most patients the proportion reaches 5 or 10 per cent; it may, however, be 25 per cent or even higher. Edema of the face is common and there may be general dropsy without albuminuria. Affected children, besides being very backward in physical development, are dull, inattentive and entirely wanting in physical or mental energy. The appetite is sometimes absent; but more characteristic is the craving, not only for every kind of food, but for such articles as clay, dirt, chalk, etc.

Death may be due to the progressive failure of nutrition or to intercurrent disease.

Prophylaxis in the individual consists chiefly in the protection of the feet of persons living in an infected district, by wearing shoes. The remedy of choice for hookworm at the present time is tetrachlorethylene. It is given in capsules by mouth; 0.5 to 1.0 c.c. may be given to a child of five years. It is preceded by a twenty-four-hour period of starvation and is followed by a cathartic two to three hours later. This drug has been widely used and appears to be most satisfactory; a pure and reliable preparation must be employed. In the event that tetrachlorethylene is not available carbon tetrachloride is probably the drug of choice. The only contra-indication is when massive infection with round-worms is present at



the same time. Carbon tetrachloride should never be followed by any kind of oil or any fluid containing alcohol. The dose for children is  $\mathfrak{m}$  v to  $\mathfrak{m}$  vii administered on sugar; it should be preceded by a period of starvation and followed by a saline cathartic. Toxic reactions require vigorous treatment with large doses of calcium.

**Trichuris Trichiura—Whipworm.**—This is not a common invader, and from a symptomatic point of view is unimportant. Either the ova alone or both worms and ova may be found in the stools. The treatment is the same as for round-worms.

**Trichinella Spiralis.**—Trichinosis is more common in this country than is generally supposed. The finding of an occasional encysted larva is not infrequent at postmortem examinations, but only in a few of these cases has the infestation been severe enough to produce symptoms during life. In children, however, the disease is certainly rare. The diagnosis has been established with certainty but twice in the pediatric service of the Johns Hopkins Hospital. Adult worms are almost never found in the stools; the embryos are deposited by the adult female directly in the lymph spaces of the small intestine. The principal symptom is muscle tenderness, produced by invasion of striated muscle tissue by the larvae; eosinophilia is almost invariably present. Cases of invasion of the meninges have been described. A positive diagnosis can seldom be established without biopsy.

**Intestinal Myiasis.**—The larvae or “grubs” of various insects sometimes appear in the stools of infants or children as the result of contamination of food with eggs and maturation during their passage through the intestinal canal. The bluebottle fly is frequently responsible. No symptoms are produced, and the discovery calls only for more careful supervision of the hygiene of the food.

**Lambia (Giardia) Intestinalis.**—The frequency of occurrence of this flagellate in the stools of children is difficult to state, for there are few communities where reliable statistics have been collected. Maxcy studied the incidence of this parasite in children admitted to the wards of the Harriet Lane Home in Baltimore. He was able to demonstrate it in about 20 per cent of all admissions. During the first year of life, the parasite was infrequently found. He found no convincing evidence that this organism was responsible for chronic diarrhea. In most instances there were no intestinal symptoms, even though the number of parasites was large. There are reports in the literature, however, which suggest that this organism may occasionally be the cause of a protracted diarrhea. Various arsenical preparations have been used to get rid of these parasites, with limited success. After a period of years they tend to disappear spontaneously, and are rarely found in adults.

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## CHAPTER XXXI

### DISEASES OF THE RECTUM AND ANUS

#### MALFORMATIONS

In Figure 44 are shown the usual varieties of malformation of the rectum. The most frequent is atresia of the anus (1). In this the cutaneous septum has not been absorbed, but the intestine is normal to its lower extremity. This form is readily

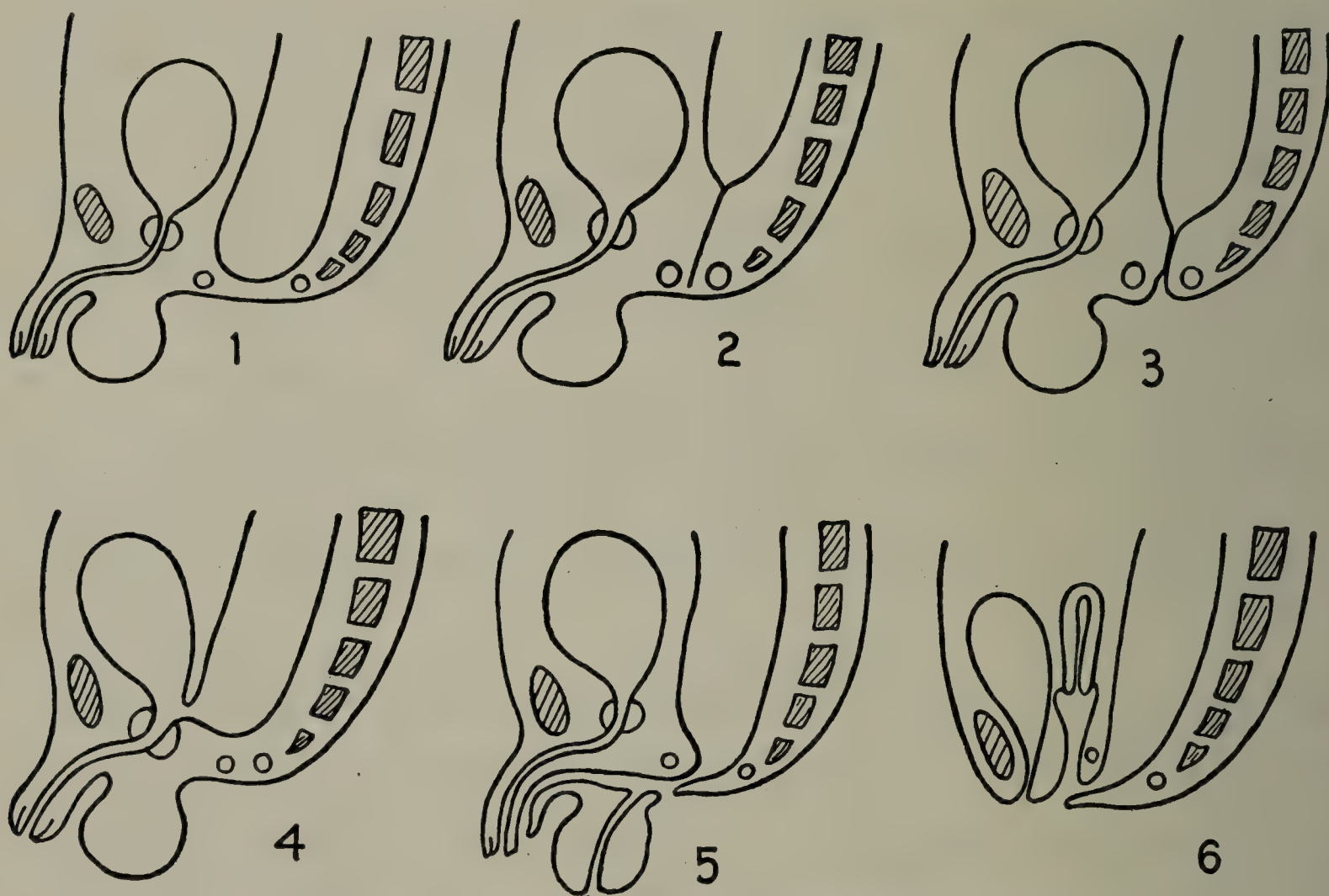


FIG. 44.—MALFORMATIONS OF THE RECTUM AND ANUS (AFTER BROMAN).

(1) Occlusion of the anus. (2) Occlusion of the rectum and anus. (3) Occlusion of the rectum alone. (4) Fistulous communication with the bladder, forming a cloaca. (5) Accessory openings in the perineal raphe anterior to the anus. (6) Rectovaginal fistula.

curable by a surgical operation. In the next variety (2) the occlusion involves the lower part of the rectum as well as the anus. In (3) the cutaneous orifice and the lower part of the rectum are normal, but a membrane separates this portion from the upper part of the gut; this is usually situated within two or three inches of the anus. The bulging of the lower part of the distended intestine can usually be felt by the finger in the rectum, and a simple division of the membrane by a knife may relieve the condition. The other forms are more serious. Instead of atresia of the



rectum there may be stenosis of varying degrees, giving rise to the usual symptoms of stricture. This is often curable by dilatation.

## PROLAPSUS ANI

Under this term are included two conditions. In the first, or partial prolapse, there is simply an eversion of the mucous membrane, which protrudes beyond the sphincter. In the second, a complete prolapse, there is invagination of the rectal wall for a variable distance, usually two or three inches.

**Etiology.**—Prolapse is most common in children during the second and third years. Its frequency in early life is partly due to the lack of support furnished by the levator-ani muscles. It also occurs very readily when the ischiorectal fat is scanty; it is therefore often seen in children suffering from malnutrition. Prolapse of the rectum is most frequently found in the course of or following dysentery. The exciting cause may be anything which provokes severe and prolonged straining. This may be either the tenesmus accompanying inflammation of the rectal mucous membrane or chronic constipation. It may come from phimosis or stricture of the urethra, and it is a very frequent symptom of stone in the bladder.

**Symptoms.**—Prolapse usually occurs during the act of defecation. It is generally easily produced, and shows a great disposition to return with every stool. In obstinate cases the bowel comes down at other times. The appearance of the tumor varies with its size. In the slighter form there is simply a ring composed of a fold of mucous membrane surrounding the anus. In the more severe form there is a flattened, corrugated tumor, usually about the size of a small tomato. The mucous membrane covering the tumor is of a deep purplish-red color, and bleeds readily. It may be the seat of catarrhal or membranous inflammation. The diagnosis in most cases is easy, although the tumor has been confounded with polyp and intussusception. Careful local examination in prolapse shows the mucous membrane of the protruding mass to be everywhere continuous with the skin of the anus.

**Treatment.**—In most cases reduction is easily accomplished by laying the child upon his face across the lap and making gentle pressure upon the tumor with oiled fingers. The application of cold, either by means of ice or cold cloths, is of assistance in cases which are not at once reduced by pressure. After reduction, in the milder cases the child should be kept upon his back for at least an hour. When the tumor tends to come down with every stool, special attention should be given at this time. If an infant, the bowels should always move while the child lies upon his back, and during defecation the buttocks should be pressed together by a nurse. Some form of restraint which prevents flexion of the thighs is helpful in preventing straining with relaxation of the levator ani. Older children should use an inclined seat placed at an angle of about forty-five degrees, but should never sit upon a low chair or assume any position in which straining is easy. After defecation the patient should lie down for at least half an hour. Constipation should be controlled in the usual way. If there is diarrhea, tenesmus may be relieved with irrigations of starch or a 4 per cent solution of tannic acid or by the use of opium suppositories.



In the most severe cases the bowel not only protrudes during defecation, but also in the interval, and it may be down for days at a time. Such cases are rarely seen except in infants who have very flabby muscles, and but little adipose tissue at the floor of the pelvis. Reduction is sometimes difficult in cases when the prolapse has lasted a long time. It is often facilitated by painting the protruding part with a solution of epinephrine, and then dilating the sphincter by passing the finger into the central opening of the tumor. After reduction, suppositories containing from  $\frac{1}{4}$  to  $\frac{1}{2}$  grain of cocaine may be inserted. A firm pad should be applied over the anus, held in position by a T-bandage, or the buttocks may be strapped together with adhesive. For several days at a time a short rubber tube may be kept in the rectum, held in place by adhesive plaster. The bowels should be kept freely open. The injection of ethyl alcohol into the tissues of the ischiorectal fossae has been advocated. Amputation or excision is not required in children.

### FISSURE OF THE ANUS

This is not a very uncommon condition in children. The most frequent cause is the passage of a large, hard, fecal mass. Sometimes it results from traumatism inflicted with the nozzle of a syringe while giving an enema. It may be produced by the scratching excited by pinworms. In the beginning there is a simple tear at the margin of the anus. The laceration which is produced usually heals promptly; but if the cause is repeated, healing is prevented, and there is finally produced a linear ulcer, or a true fissure, which may last for some time and be a source of great annoyance.

A fresh fissure has the appearance of any other tear at a mucocutaneous orifice. One of longer standing has a gray base, slightly indurated edges, often discharges a small amount of pus, and bleeds a drop or two with nearly every movement of the bowels. The most constant symptom is pain, which usually occurs with the act of defecation and continues for some time afterward. It is most severe when the fissure is just at the margin of the sphincter, and leads the child to resist every inclination to have the bowels move, so that it becomes a cause of chronic constipation, which condition again greatly aggravates the fissure. The pain is often referred to other parts in the neighborhood.

The treatment is simple and usually efficient. It consists in cleanliness, overcoming the constipation, and touching the fissure with silver nitrate, preferably with the solid stick. If the case is not speedily relieved by such measures, the sphincter should be stretched as in adult patients.

### PROCTITIS

Proctitis, or inflammation of the rectum, usually occurs with inflammation of the rest of the large intestine, but it may occur alone. It is to the cases in which only the rectum is involved that the term is generally applied.

The causes are for the most part local. A frequent one in infants is the use of irritating injections or suppositories, either for the relief of constipation or as a means of administering certain drugs. We have seen marked cases in infants following the prolonged use of glycerin suppositories. It is sometimes caused by



traumatism, especially by the careless giving of an enema. It accompanies pinworms. In certain cases it may result from direct infection through the anus. This may be from a gonococcus inflammation extending from the vagina or urethra, or from an infection due to other bacteria, particularly in cases of measles, scarlet fever, and diphtheria; or, finally, it may be due to syphilis. Proctitis may be catarrhal, membranous, or ulcerative.

The pathological conditions are the same as in inflammation of other parts of the intestinal tract. By the introduction of a speculum, or by simply everting the mucous membrane, it is seen to be reddened, swollen, and bleeds easily. In some cases there is a copious secretion of mucus; in others it is relatively dry and covered by patches of membrane; while in still others there are ulcers, sometimes follicular and superficial, at other times larger, deeper, and more intractable. Follicular ulcers are often localized just within the anal ring. Single ulcers, or very chronic ones, suggest a tuberculous origin.

The symptoms are chiefly local, although a condition of general irritability may result from the local condition. There is pain with defecation. The stools usually contain mucus, often as a clear, jelly-like mass, sometimes in the form of a cast, but not generally mixed with the stool. In severe forms pus is present. There are usually traces of blood, sometimes quite large hemorrhages. Tenesmus is common, as is also prolapsus ani. The skin in the vicinity is irritated by the discharges, especially in infants. If the cause is pinworms, there may be intense itching.

The duration of the condition is indefinite, depending upon the cause. It may be a few days or many months. The inflammation may extend from the rectum to neighboring parts, leading to ischiorectal abscess.

**Treatment.**—In cases of catarrhal or membranous proctitis injections of some bland fluid should be employed, such as starch solution, a mixture of oil and lime water, or a warm 1 per cent salt solution. The local cause, if one exists, should be removed. When the tenesmus is severe, suppositories of opium may be used. Cases associated with pinworms are especially obstinate; here the treatment is to be directed first toward the elimination of the worms, and afterward to the proctitis.

Cases of ulcer, and chronic cases in general, require more drastic treatment. Rest in bed is essential. The stools should be kept soft by adjustment of the diet and a judicious use of mild laxatives. One or two ounces of liquid petrolatum should be injected into the rectum each night, to be retained. In addition the bowel should be irrigated once a day with warm salt solution, to be followed by the local application of 1 per cent boric acid solution, 2 per cent tannic acid, or a 0.2 per cent solution of silver nitrate. Single ulcers may be directly cauterized with solid silver nitrate.

## ISCHIORECTAL ABSCESS

This is not a very rare condition even in infancy. Infection by direct extension from the rectum seems to be the most common cause, although sometimes the abscess may be traced directly to traumatism.

Essentially the same varieties of inflammation are seen in early life as in adults.



Most of these cases recover promptly after simple incision and cleanliness, fistula being a rare sequel.

### RECTAL POLYP

Polyps are rarely seen in children, but, when present, may be the cause of rather obscure symptoms. The most important one is hemorrhage. This at first occurs at intervals of days or weeks. The amount of blood lost is from a dram to an ounce or more. Later, the hemorrhages become more frequent and may be almost continuous, although rarely profuse enough to produce serious symptoms. The diagnosis of polyp is made only after a local examination. Sometimes the tumors are within the reach of the finger; in other cases a proctoscope must be employed. Spontaneous cure often takes place by the sloughing of the tumor, after which the bleeding soon ceases. In other cases operation is necessary.

### HEMORRHOIDS

These are not often seen in children, although they occur in those as young as three or four years, and in some cases may even be congenital. The principal cause is chronic constipation, rarely diarrhea. The tumors are generally small and external, the chief symptom complained of being pain on defecation. Bleeding sometimes accompanies the pain, but the hemorrhages are usually small. The treatment is to be directed toward the underlying cause. In most of the cases this suffices to cure the condition. Operation is rarely required in young children, although neglect may make this procedure necessary. A local prominence of the perineal raphe should not be mistaken for true hemorrhoids.

### INCONTINENCE OF FECES

Inability to control the fecal evacuations is seen in certain cases of paraplegia due to myelitis, after injury of the lumbar portion of the spinal cord, and in spina bifida. It may occur with the usual or with the occult variety, associated with incontinence of urine, when there is no paralysis of the extremities. It is also seen in acute disease, as in coma from any cause and in extreme adynamia. It is not uncommon in severe attacks of chorea. It may sometimes be seen after operations for atresia of the anus or rectum. In all these conditions incontinence of feces is a symptom giving rise to much annoyance and needing careful attention. Uncleanliness with reference to excreta, seen in idiocy, can hardly be classed as incontinence.

Besides these familiar forms, the condition is sometimes seen from causes somewhat resembling those of incontinence of urine. The tone of the sphincter becomes so feeble that it does not resist even the slightest impulse to evacuate the rectum. The discharge may take place with but little warning, and may occur either by day or night. In some cases a local cause exists, such as stretching of the sphincter by an old rectal prolapse. It has followed overdistention of the rectum from prolonged chronic constipation. It has been associated with vesical calculi. It is sometimes seen after severe acute illness, as a result of a loss of general muscular tone, particularly if laxatives have been used freely. In certain children it has been known to persist from infancy until the age of ten or twelve



years. It may come on as a somewhat acute condition in highly nervous patients with poor general nutrition. The treatment is rather unsatisfactory, except in recent cases and in those due to local causes which can be removed. If the condition is of mental origin, due to neglect or careless training, it should be treated by psychotherapy. (See Enuresis, page 648.) Atropine may be beneficial at times.

Patients who are receiving liquid petrolatum by mouth in the treatment of constipation may find difficulty in retaining it.

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## CHAPTER XXXII

### DISEASES OF THE LIVER

**Anatomical Considerations.**—In early life the liver is relatively larger than in the adult. At birth it constitutes 4.0 to 4.5 per cent of the body weight; at the age of one year it constitutes 3.0 to 3.5 per cent of the body weight and after puberty it comprises between 2.5 and 3.0 per cent. The upper border must be made out by percussion, the lower border either by palpation or percussion. During the first year the liver is usually palpable 1 to 2 centimeters below the costal margin in the mammary line. It gradually recedes and is seldom palpable in normal subjects after three years of age.

**Physiology of the Liver.**—The functions of the liver are many-sided. It secretes the various constituents of the bile, some of which are formed *in situ*. It forms glycogen from monosaccharides and is an important storehouse for this reserve carbohydrate. It stores fat, and is believed to desaturate lipoids before they can be burned. It forms plasma proteins and many of the blood coagulation factors. Many harmful substances are “detoxified” in the liver and excreted in harmless form; hence it doubtless plays an important rôle in immunity. Deamination of amino-acids is usually believed to take place exclusively in the liver, but according to Folin and Berglund it may occur elsewhere. This list of functions is far from complete.

The infant’s liver carries on all these functions and in addition some that are peculiar to early life. In fetal life the liver is an important hemopoietic organ. Normally this function does not persist after birth, but in premature infants and in those with congenital syphilis or anemia, blood formation may continue for many weeks.

During the greater part of the first year the liver serves as an important storehouse for iron. This iron store cares for the infant’s needs at a time when his diet is ordinarily deficient in this element.

**Symptoms of Hepatic Insufficiency.**—Impairment of liver function can often be suspected clinically, as when a large or irregular liver is felt. The most obvious symptom of hepatic disease is, of course, jaundice.

**Jaundice.**—Jaundice does not necessarily mean that liver function is impaired; it may be due to an abnormal load which is put upon the liver, more bilirubin being formed than the liver is able to excrete. Two general types of jaundice may be distinguished: (1) *jaundice due to obstruction* to the flow of bile, which may be intra- or extrahepatic; (2) *hemolytic jaundice*, in which there is produced more bilirubin than the normal liver cells are able to secrete. In the obstructive variety bilirubin is likely to be found in the urine; if the obstruction is sufficiently complete the stools are clay-colored. Jaundice is most conveniently measured by the van den Bergh reaction, which enables one to determine not only the quantity



of bilirubin in the blood, but also to distinguish between the obstructive and hemogenous varieties. The test is carried out by adding to blood serum the Ehrlich "diazo-reagent." If the color of diazo-bilirubin develops at once, the reaction is a *direct* one. Such a reaction is obtained with blood serum in obstructive jaundice; in normal bile the direct reaction is obtained. The *indirect* or *biphasic* reaction may be tried if the direct one fails. This is carried out by precipitating the plasma proteins with alcohol, and adding to the supernatant fluid the Ehrlich reagent and more alcohol, whereupon the color of diazo-bilirubin promptly appears. The small amount of bilirubin present in normal plasma gives an indirect reaction; in hemolytic jaundice, a strongly positive reaction is so obtained.

This difference in the behavior of bilirubin in the two varieties of jaundice has recently been explained by Barron and Harrop. They have pointed out that an indirect reaction becomes direct in the presence of bile salts or of any surface tension lowering substance. Only in the cases of obstructive jaundice do bile salts find their way into the blood in appreciable quantities. Under normal conditions the serum proteins adsorb bilirubin, and prevent direct or immediate coupling with the diazonium salt; hence only the indirect reaction is obtained. In the presence of bile salts, the adsorbing protein becomes saturated and can no longer adsorb bilirubin; hence the direct reaction is obtained.

Bilirubin appears in the urine in quantity only when the direct reaction is obtainable, *i.e.*, in obstructive jaundice. Free bilirubin, such as occurs when bile salts are present, is easily excreted by the kidney, whereas bilirubin adsorbed by the serum proteins is not so excreted.

Obstructive jaundice always indicates hepatic insufficiency, but in hemolytic jaundice this is not necessarily the case.

In cases of severe jaundice, usually obstructive in origin, there may occur itching of the skin, bradycardia, and a prolonged bleeding time, perhaps with hemorrhagic manifestations. These have been attributed to the presence of bile salts or bile pigment in the blood. Other symptoms that may accompany severe jaundice can be attributed to hepatic insufficiency. Thus, in complete obstruction of the bile ducts, absence of bile salts from the intestine prevents to some extent the proper activation of pancreatic lipase, but marked impairment of fat-splitting with steatorrhea occurs only when the pancreatic secretions themselves are defective. Under conditions of extreme liver damage, fever, convulsions, coma and other nervous symptoms may be seen. Although these often pass under the term *cholemia*, it is by no means certain that they represent intoxication by some constituent of the bile; it is more probable that they are due to some disorder of liver function.

**Liver Function Tests.**—Since the various functions of the liver do not fail in parallel degree, no single test will give information about the organ as a whole. Moreover, none of the tests employed are sensitive enough to detect minute lesions; the liver has a large factor of safety and considerable damage must be done before it will be revealed by any test. The most useful tests are the *carbohydrate tolerance tests*, which measure the ability of the liver to form glycogen from various monosaccharides, and *dye excretion tests*, which depend upon the ability of the liver to excrete certain dyes when injected into the blood stream.



*Carbohydrate Tolerance Tests.*—These may be carried out with glucose, levulose or galactose. The tolerance was formerly tested by the appearance of sugar in the urine; more valuable information can be obtained by following the total blood sugar. If glucose is ingested (1.6 gram per kilo) the capillary blood sugar rises to 140 or 160 milligrams per cent during the first half-hour and returns to the original level within two hours. The venous blood shows a less marked rise. If identical amounts of levulose are given a higher curve is obtained and galactose gives a still higher curve, since this sugar is least readily converted into glycogen by the liver. Hence if comparable curves are to be obtained less sugar should be given when levulose is used, and an even smaller quantity when galactose is used. There has been little uniformity in the quantities of these various sugars used in tolerance tests. One must therefore be familiar with the normal response to a given dosage before any deductions can be drawn. There is reasonably good evidence that impaired liver function (glycogenesis) is revealed sooner by the levulose than by the glucose test. In catarrhal icterus, and icterus associated with acute infections, it has been claimed that the galactose test is even more valuable. Further observations are needed to determine the respective value of these tests. Levulose and galactose can be determined in the blood after their ingestion; this procedure makes the test somewhat more delicate, but adds to the difficulties of the analyst.

*Dye Excretion Tests.*—Certain dyes are secreted from the blood stream by the liver. Of these bromsulphalein has been most generally used for liver function tests. The dye is injected intravenously and its concentration in the blood serum is followed at intervals. With the quantity recommended by Rosenthal, disappearance is normally complete in one-half hour. Studies that have been made in children (Aballi *et al.*; Herlitz) indicate that during the early weeks of life the liver shows an impaired ability to excrete dye as judged by adult standards.

Probably the most satisfactory dye excretion test (in the absence of jaundice) is the bilirubin excretion test introduced by von Bergmann and Eilbott and studied in this country by Harrop and Barron. Pure bilirubin (1 milligram per kilo) is injected intravenously, its level in the blood being followed by the van den Bergh reaction. Normally the original level is regained within four hours; an elevation at the end of this period is pathological. Harrop and Barron found this test more sensitive than the bromsulphalein test or the levulose tolerance test.

*Urobilinuria.*—Urobilinuria has also been used as a test of hepatic function. Urobilin is normally brought to the liver by the portal vein, where it is reoxidized into bilirubin. When this function fails, urobilin enters the blood and escapes in the urine. The test is not a particularly satisfactory one, since urobilinuria is also found in conditions of increased blood destruction. In the latter condition there is a marked increase of urobilin in the stools. In order to rule out excessive blood destruction as a cause of urobilinuria it is necessary to make a complete collection of the stools over a period of some days and determine the pigment in the feces. This has largely been abandoned as a test of liver function.

*Other Tests.*—Other tests for liver function have been proposed from time to time, such as the determination of fibrinogen in the plasma, of fibrinolytic ferment in the plasma, of blood lipase. In extreme liver injuries leucine, tyrosine and other amino-acids may appear in the urine; in the hope of detecting lesser injuries, amino-acid tolerance tests have been used. Lactic acid tolerance tests have been employed. Bile acids can be detected in the blood and urine in some patients with obstructive jaundice. The analytical procedures, however, are not entirely satisfactory. The ability of the liver to form conjugated sulphates has been tested by studying the tolerance to phenol and to thymol. So far none of these tests has proved of great practical value.

In view of the lack of parallelism between the findings in various liver function tests, it might be expected that multiple tests would reveal definite patterns characterizing one or another disease entity. Up to the present time, this hope has not been realized.



**Malpositions.**—The liver may be displaced downwards by contraction of the chest, as in rickets, or by accumulations of fluid in the chest. This may occur in emaciated infants owing to relaxation of the abdominal walls. Downward displacement should not be confused with hepatic enlargement. Upward displacement is less frequent and usually depends upon ascites, abdominal tumors, or eventration of the diaphragm.

The liver may be found upon the left side in cases of complete transposition of the viscera. In cases of diaphragmatic hernia the organ may be found in the thoracic cavity.

**Malformations.**—Congenital malformations relate chiefly to the bile ducts. There may be atresia at the point where the common bile duct opens into the duodenum, the duct may be represented by a fibrous cord, or it may be absent altogether. In many cases the only lesion is of the common duct; in others it is associated with an impervious hepatic or cystic duct; in still others the common duct is normal, but the hepatic ducts are impervious. In place of atresia, there may be various grades of stenosis. Practically all permutations and combinations of these variants have been described.

At autopsy all the organs are found intensely jaundiced, particularly the liver. Even the spinal fluid may contain bilirubin. In patients dying early, within the first month or so, the liver is greatly swollen and on microscopic section shows bile stasis; when the condition has lasted longer, more or less marked biliary cirrhosis will be found. Chronic interstitial hepatitis of severe degree was reported in 9 of the 50 cases collected by Thomson. The size and content of the gall-bladder depends in each case on the state of the ducts: in atresia of the cystic duct it is usually small, containing only thick mucus; in obstruction of the common duct below the cystic branch it may be greatly distended with inspissated bile. In patients who have lived several months, the spleen is usually enlarged and contains increased connective tissue. Secondary changes in the pancreas have also been described.

The most striking symptom is jaundice, which begins to be noteworthy about the end of the second week of life when the expected recession of physiological icterus fails to materialize. In spite of minor fluctuations, probably due to variations in the rate of blood destruction, it increases relentlessly until, if the patient lives long enough, the skin and sclerae become of a bronzed, olive-green color. In the first days of life normal-looking meconium may be passed, but thereafter the stools are gray or chalky and, if the obstruction is complete, fail to give chemical or physical tests for bile pigments. Greenish discoloration of the stools dependent on other causes must not be mistaken for evidence of the presence of bile. The urine is colored a dark brown or bronze by bilirubin; urobilinuria does not occur. The breath often has a musty odor as of raw liver. The liver, as a rule, is much enlarged, its edge smooth and firm. The spleen may be palpable. The cellular elements of the blood usually show no change except for some degree of secondary anemia. The bleeding and clotting time are often prolonged. The plasma contains enormous amounts of bilirubin, sometimes as much as 50 milligrams per 100 c.c. The van den Bergh gives a strong direct test. In patients with parenchymatous changes in the liver the blood sugar is often found to be low. For the



first few weeks or months of life the nutrition of these patients is surprisingly good. Vomiting is not prominent, the appetite may continue to be good for a long time, and they are more prone to show constipation than diarrhea. Protein metabolism is not greatly affected, but fat absorption is poor; if the pancreatic juice does not reach the intestine, much neutral fat appears in the feces. If there is no interference with pancreatic secretion the fecal fat is fairly well split. Carbohydrates are well absorbed, but the intermediary metabolism is disturbed in proportion to the degree of cirrhosis. Eventually the rate of gain slows down more and more and the weight becomes stationary. Sooner or later many of these patients go into a so-called cholemic state, manifested by convulsions and a tendency to hemorrhage. Of Thomson's 50 cases, 9 lived less than a month, and only 18 over four months. We have seen 1 patient who lived for eleven months.

Stenosis of the ducts causes a clinical picture similar to the above, differing mainly in degree. The diagnosis of complete occlusion is, as a rule, not difficult, though the exact location of the obstruction cannot be determined without exploratory operation. When the occlusion is incomplete, the differential diagnosis from hepatitis of syphilitic or other origin is often difficult.

A small proportion of these cases (16 per cent according to Holmes) is amenable to surgical treatment. In any patient in whom the diagnosis is made, exploratory laparotomy should be performed without delay. It is a mistake to delay in the hope of improving the patient's nutrition; the cirrhosis, which is the real source of danger, only becomes thereby more severe.

### INFECTIOUS JAUNDICE

This is a benign infectious disease of unknown etiology which occurs both sporadically and in epidemics. Notable epidemics occurred in the United States in 1812, 1839, 1857-58 and in 1920-22. Numerous ones have been described in Europe. The disease is rare in infancy, but is not uncommon in children over three years of age; curiously enough, it occurs more frequently in the autumn months. It is also called catarrhal jaundice and epidemic icterus.

No infectious agent has been identified, but organisms of the colon group have been suspected, since certain epidemics have been traced to contaminated drinking water. Second attacks are almost unknown.

Pathological observations upon uncomplicated cases are rare. Eppinger, in 1908, reported a postmortem examination of a young adult who met an accidental death; he found a catarrhal inflammation originating in the duodenum and spreading up the bile ducts. One or two more recent observations have not confirmed this finding, but have revealed a hepatitis. The jaundice is definitely of the obstructive type, but in some cases there is evidence of increased hemolysis as well.

**Symptoms.**—The symptoms are quite uniform. The disease begins with vague feelings of lassitude, irritability and anorexia. There is slight fever, and as a rule digestive symptoms—nausea and perhaps vomiting. The tongue is coated and the breath foul. There may be abdominal pain localized in the right upper quadrant; sometimes this is quite severe. The bowels are usually constipated, but occasionally there is diarrhea. The condition is generally regarded as an attack of indigestion until jaundice makes its appearance, usually on the third or fourth



day. It is first seen in the conjunctivae. Sometimes the dark greenish-brown color of the urine, from the presence of bilirubin, attracts attention before the icterus itself. Bilirubin is greatly increased in the blood serum; it can frequently be detected by direct inspection. The van den Bergh reaction is usually direct, but sometimes biphasic. The stools are paler than normal, and in fully half the cases they are clay-colored at the height of the attack. At this stage prostration is marked, the patient feeling utterly wretched. He may complain of headache, nausea, or flatulence. The liver is usually palpable and sometimes tender; the spleen may be slightly enlarged. Itching of the skin and bradycardia are uncommon in children. Most patients run an afebrile course after the first three or four days of symptoms. There is no characteristic change in the leukocyte count.

The duration of the disease is about two weeks, the general symptoms disappearing before the icterus. A palpable liver may outlast the icterus. As the jaundice diminishes, bilirubin in the urine is sometimes replaced by urobilin. Relapses are occasionally seen. The diagnosis rarely offers any difficulty. These cases form a definite clinical group which can be differentiated, on the one hand, from jaundice accompanying various infectious diseases, and on the other from the severe hemorrhagic jaundice of spirochetal origin (Weil's disease). The prognosis is almost uniformly good. Occasional instances of acute yellow atrophy with a fatal termination are seen in epidemics. Cirrhosis of the liver is a very rare sequel.

**Treatment.**—Treatment is purely symptomatic. Fats should be restricted, since they are badly borne and aggravate vomiting. Fruits, carbohydrate gruels, skimmed milk and some meat can usually be tolerated. If there is vomiting it may be necessary to withhold food for a time; parenteral fluids are rarely needed. Cathartics are sanctioned by custom, but their value may well be doubted. Abdominal pain is rarely so severe that it cannot be relieved by counterirritation. A restricted diet should be continued until a healthy appetite returns.

### NEW GROWTHS OF THE LIVER

New growths of the liver are rare in children and usually represent metastases from malignant neoplasms primary in other organs, particularly the adrenals. We have seen a neuroblastoma in the liver of a child of six weeks, and it has been reported as early as eighteen days. In most of the cases there is simply a slowly increasing abdominal tumor and progressive asthenia. Benign hemangiomata, giving rise to no symptoms during life, are occasionally found at autopsy. Cysts and adenomata have been described, but are exceedingly rare. Primary sarcoma has been observed at so early an age as to make it practically certain that the condition was congenital.

### ACUTE YELLOW ATROPHY

This form of hepatic disease is very rare in children. The etiology is quite obscure. Cases have been reported in children as young as three months. An occasional case is met with in epidemics of benign infectious jaundice. The symptoms and course of the disease are essentially the same as in adults. A condition closely allied to this is occasionally seen as a result of the administration of chloroform or the ingestion of yellow phosphorus.



### CONGESTION OF THE LIVER

Congestion of the liver occurs from the same causes in children as in adults. Chronic passive congestion is more common, and is usually secondary to general venous obstruction dependent upon heart disease, atelectasis, or other pulmonary conditions, particularly chronic pleurisy, chronic interstitial pneumonia, and emphysema. Chronic congestion of the liver causes no characteristic symptoms except a moderate enlargement of the organ with some pain and tenderness. The treatment is that of the primary disease.

### ABSCESS OF THE LIVER

In 1890 Musser found but 34 recorded cases of abscess of the liver in children under thirteen years. Since that time a few additional cases have been reported. In the above collection, there have not been included cases of suppurative hepatitis in the newly born.

As in adults, abscess of the liver may result from traumatism, or it may be secondary to suppurative pylephlebitis, which depends upon a focus of infection in the umbilical vein, or in some part of the abdomen from which the branches of the portal vein arise. Pylephlebitis may follow appendicitis, it may follow typhoid fever directly, or be due to suppuration of the mesenteric glands or peritonitis following typhoid. In seven of the cases collected by Musser the disease was due to migration of round-worms from the intestine into the hepatic ducts. Large liver abscesses are very rare in this country except in those regions where amebic dysentery prevails. Great numbers of minute abscesses are sometimes found as a result of suppurative thrombosis of some vein such as the lateral sinus following middle-ear disease. In many cases no adequate cause can be found.

In the cases occurring in pyemia and in those associated with pylephlebitis there are usually several abscesses; in traumatic cases generally but one. If untreated, the majority of cases prove fatal either from cachexia or from rupture into the pleura or peritoneum. Spontaneous cure may take place by rupture into the intestine.

**Symptoms.**—Occasionally abscess of the liver is latent, but in most of the cases the symptoms are marked and sufficiently characteristic to make the diagnosis a matter of no great difficulty. The most constant general symptoms are chills, which may be single, but are usually repeated; fever, which is commonly of the hectic variety and followed by sweating, prostration, vomiting, diarrhea, and cachexia. Jaundice is present in less than half the cases, and is rarely intense. The liver is almost invariably sufficiently enlarged to be easily made out by palpation or by percussion; the enlargement in most cases is chiefly downward. Pain is quite constant and frequently intense, but not always in the region of the liver. Tenderness over the liver is usually present. A positive diagnosis of hepatic abscess is to be made only by aspiration and the withdrawal of a fluid having the characteristics of "liver pus." With an abscess occupying the convexity of the right lobe there may be cough and dyspnea from pressure, or pleurisy from extension of the inflammation through the diaphragm, or from rupture into the pleural cavity. The usual duration of abscess of the liver after the beginning of the symp-



toms is from one to two months. The prognosis is not good, but depends upon the cause; the pyemic cases are usually fatal.

**Treatment.**—This is purely surgical, unless the abscess is due to an amebic infection. In that case specific treatment should also be given as advised under Amebic Colitis. Cases have been reported where, after undoubted evidences of abscess have been present, recovery has followed the use of emetine alone. Without operation, however, the chances of recovery are slight. A small number of cases have been cured by aspiration, but in the vast majority of abscesses due to any cause only incision and drainage are to be depended upon; if the abscess is accessible, this should be resorted to as soon as the diagnosis is established.

## CIRRHOSIS

Cirrhosis of the liver is rare in this country in the first few years of life though it is met even in the first year. After the age of seven years it is seen with increasing frequency. There are certain localities where infantile cirrhosis is exceedingly common as, for instance, in parts of India. In Calcutta there are several hundred deaths from the disease reported each year. It would seem that some local cause must be responsible for this extraordinary frequency. Cirrhosis in infancy may be familial. We have seen a child of six months of age suffering from cirrhosis. Two older children had died from the same disease a few years before. Several such instances are to be found in the literature. No satisfactory explanation has been offered for these familial cases or indeed for the majority of cases of cirrhosis. A few in early life are to be referred to alcohol, a few to congenital syphilis, or to some variety of infectious hepatitis, but in most instances no definite cause can be discovered.

The anatomical features of cirrhosis in early life are essentially the same as in adults but a clear differentiation between the two types (portal and hypertrophic biliary) is frequently not possible. When the alterations are of the portal type the regeneration of hepatic tissue is frequently not very striking and the infiltration with fat is often so intense that the liver may remain large and smooth. In our experience the small hobnail-liver of cirrhosis in children is exceptional. The associated lesions, enlarged spleen, gastric and esophageal varices, are present as they are in adult life but an extensive compensatory venous circulation is unusual.

**Symptoms.**—These are much the same as in adult life. In the beginning of the portal (Laënnec) type, the symptoms are very indefinite. There are digestive disturbances, loss of weight, pallor and a slight icteric tint to the skin. Both spleen and liver are usually enlarged. Enlargement of the spleen may be the first and most striking symptom. It may be months and sometimes years before other evidences of cirrhosis appear. To this succession of symptoms the term "Banti's disease" is often applied. Gradually more ominous evidences of cirrhosis appear. The abdominal veins become prominent, the liver may diminish in size though it usually can be felt, ascites may develop and there may be vomiting of blood or the passage of tarry stools. Death occurs from hemorrhage or cachexia. The progress of portal cirrhosis in children is much more rapid than it is in adult life.

In biliary cirrhosis jaundice appears early and may be the first symptom to claim attention. The liver and spleen are both found enlarged. A febrile reaction



is frequent but usually not continuous. It occurs in so-called “crises” that last a few days and in which all the symptoms are exaggerated. We have seen clubbing of the fingers in a few cases; ascites may develop but it is uncommon. The course is progressively downward but marked by periods of exacerbation and remission. Loss of flesh and strength occurs rapidly toward the close and the jaundice becomes intense. Death takes place after several months, or a few years, from cachexia, or in coma with evidences of cholemia. Liver function tests (see p. 329) may show impairment of function.

**Treatment.**—Medicinal treatment is of avail only with patients who are syphilitic. These should be put upon antisyphilitic remedies in full doses. The treatment in other respects is symptomatic and palliative. The ascites may require paracentesis as in adults.

FATTY LIVER

Fatty infiltration of the liver is generally a secondary condition in early life, and causes no symptoms by which it can be positively recognized. Considerable discussion has of late arisen regarding its frequency in infants. Wollstein has tabulated 345 consecutive autopsies in which the condition of the liver was carefully noted. The liver was fatty in 201, or 58 per cent. Of these autopsies, 63 were in cases of tuberculosis, in 43 of which, or 68 per cent, the liver was fatty.

The general nutrition of the 345 infants was as follows:

	Number	Liver Fatty		Liver Very Fatty, Number
		Number	Per Cent	
Wasted .....	188	104	55	17
Fairly nourished .....	80	52	65	9
Well nourished .....	77	45	59	20

These figures coincide very closely with the observations of Freeman at the New York Foundling Hospital, and indicate that fatty liver is not, as has been so often asserted, much more frequent in wasted infants than in others. The cause of this change in the liver is as yet but little understood. The literature contains several references to the occurrence of fatty liver in certain families.

The liver is moderately enlarged, smooth, with rounded edges, of a yellowish-red or a lemon-yellow color, and can be indented with the finger. A warm knife becomes coated with oil after cutting. Microscopically there is seen an accumulation of fat in the liver cells, usually irregularly distributed, but chiefly in the periphery of the lobule. Jaundice, ascites, and the other peculiar symptoms of hepatic disease are absent. The various physiological functions of the liver are not interfered with in such a way as to be recognized by symptoms.

HYDATIDS

Echinococcus disease of the liver, rare among adults in this country, is almost unknown in children. We have been able to find but 2 recorded cases in America. From 22 European cases collected by Pontou, it appears that unilocular cysts are especially frequent in young subjects. If the upper surface is affected, pulmonary



symptoms, cough and dyspnea, are usually present; if the under surface of the organ, there is pressure upon the portal vein, the vena cava, bile ducts, stomach, and intestines. This pressure may cause icterus, dilatation of the superficial abdominal veins, and sometimes ascites. The local signs are enlargement of the liver with a tumor, which is easily recognized in children because of the thin abdominal walls. The hydatid fremitus is usually obtained. By aspiration a clear fluid is withdrawn, showing under the microscope the presence of the hooklets, which establishes the diagnosis. The specific skin reaction described by Casoni may be of assistance. Occasionally cure may take place by spontaneous rupture or suppuration of the cyst, but in most cases, when left to itself, the disease proves fatal. The treatment is surgical.

### BILIARY CALCULI

Up to the age of puberty calculi are extremely rare. Of 20 cases collected by Still, 11 occurred in newly born infants or else gave symptoms during the first month of life. The most prominent symptom was intense and persistent jaundice. Nearly all died within the first month, the autopsy usually showing multiple calculi in the common duct.

The cases in older children do not differ from those in adults.

### CHOLECYSTITIS

This is rare in early life, but has been observed in children as young as three years of age. Bolling in his wide experience observed but a single instance. The association with typhoid fever has been noted in children. Cases are on record in which round-worms have set up an inflammation of the gallbladder. Tuberculosis of the gallbladder occurs occasionally. As in adults, cholelithiasis may be associated. In newly born infants minute calculi (biliary sand) are frequently found in the bile ducts, sometimes in the gallbladder. These are not to be regarded as pathological; they are passed during the first days of life without difficulty.

The symptoms of cholecystitis do not differ from those in later life; vomiting may be a prominent feature. The diagnosis is rarely made before operation. Most cases of acute symptoms in the right upper quadrant prove to be appendicitis with an undescended cecum.

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## CHAPTER XXXIII

### DISEASES OF THE PANCREAS

**Congenital Malformations of the Pancreas.**—These are rare, and involve usually the ducts. Unless there is complete occlusion of the main duct or several branches, the condition may be compatible with health. Congenital cysts may be associated. Either occlusions of this type or a congenital hypoplasia of acinar tissue may form the basis of the condition of steatorrhea already mentioned (page 214).

**Acute Pancreatitis.**—Cases of nonsuppurative acute pancreatitis have been reported in children with mumps. The diagnosis is usually based on the occurrence during mumps of severe epigastric pain, vomiting, occasionally with fever, diarrhea, and bradycardia, but in several instances it has been confirmed at autopsy or operation. Symptoms usually set in four or five days after the commencement of parotid swelling and last for about a week. The prognosis is usually good. Transient glycosuria and even diabetes have followed such attacks and in the case reported by Finizio pancreatic steatorrhea developed.

We have seen but one case of acute pancreatitis not associated with mumps. A five-months-old boy had a sudden onset of vomiting with slight fever and a great deal of severe pain, apparently referable to the abdomen. There was not much change in the stools. When first seen a week after the onset, there had been considerable loss of weight, but the original symptoms had to some extent subsided. A mass was palpable deep in the left hypochondrium that was obviously neither spleen nor kidney; the preoperative diagnosis of intussusception with incomplete obstruction was made. Operation revealed swelling and induration of the pancreas, with fat necroses in the omentum and an excess of turbid, blood-tinged fluid in the peritoneal cavity. The convalescence was stormy, but complete recovery eventually took place. At no time was there any detectable abnormality of carbohydrate metabolism beyond what one would find in a patient with any acute disease.

Acute pancreatitis has been described in connection with infectious diseases; it may be associated with migration of ascaris into the pancreatic duct. In septicemia multiple abscesses may be found in the pancreas; these do not, as a rule, cause symptoms.

**Chronic Pancreatitis.**—A diffuse fibrosis of the pancreas is not uncommon in congenital syphilis. In routine microscopic examinations of the pancreas it is by no means rare to find cellular infiltrations, particularly about the ducts, indicating a chronic inflammatory reaction of mild degree. Both of these conditions may give no symptoms during life. Tuberculosis of the pancreas sometimes occurs.

**Tumors of the Pancreas.**—These are so rare in infancy and childhood as to warrant no general statement of types or symptomatology.



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## CHAPTER XXXIV

### DISEASES OF THE PERITONEUM

#### ACUTE PERITONITIS

Acute peritonitis may occur at any period of infancy or childhood. It may even exist in intra-uterine life. In the newly born, peritonitis is seen as one of the frequent lesions of acute pyogenic infection. It is usually due to direct infection through the umbilical vessels. After the first month of life cases of acute peritonitis are occasionally seen which are apparently primary. In the great majority of these, the infecting organism is some type of pneumococcus; in others, a streptococcus. It has been maintained that the infection is an ascending one, taking place through the genital tract of girls. Primary pneumococcus peritonitis is more common in girls, but the occurrence of cases in boys is proof that some other method of entrance is possible.

The secondary form of peritonitis is more common. The most frequent of all causes is appendicitis, which should always be suspected in acute peritonitis occurring without definite cause. The primary inflammatory conditions, such as acute appendicitis, from which extension to the peritoneum may occur, are, as a rule, less common in young individuals than in adults; on the other hand, when they do occur the process of spread is more rapid and involvement of the peritoneum more extensive. Peritonitis may result not only from obstructive and inflammatory conditions of the gastro-intestinal tract, but also by extension from the pleura, by means of an empyema which burrows through the diaphragm. Peritonitis is infrequently due to infection through the female genital tract, such as a gonococcus vulvovaginitis in older girls. Any abscess in the neighborhood may rupture into the peritoneum and excite peritonitis. Those most frequent in children are connected with Pott's disease, perinephritis and cellulitis of the abdominal wall. Peritonitis is occasionally seen in pyemia from any cause, and quite frequently occurs as one of the complications of septic sore throat. It may result from traumatism, such as falls or blows, or surgical operations, and it may follow severe burns.

Peritonitis when associated with acute pneumonia may develop early and be associated with a similar inflammation of the pleura, pericardium, and sometimes the meninges. In such cases the blood culture usually shows a general pneumococcus septicemia. In other cases the peritoneum is involved late—from one to three weeks after the pneumonia—but in these cases empyema is usually present also.

A considerable number of patients with severe nephrosis develop pneumococcus or, more rarely, streptococcus peritonitis. The relationship between the two conditions is not clear, but their concurrence is far more frequent than could be accounted for by simple coincidence.



In acute rheumatic fever, the typical perivascular lesion has been described in the peritoneum, usually on the inferior surface of the diaphragm. Abdominal pain is sometimes so severe in rheumatic fever as to lead to exploratory laparotomy. In such cases it is usual to find a small amount of free fluid in the peritoneal cavity.

The bacteria most frequently responsible for acute peritonitis in children are pneumococci and streptococci. Colon bacilli are usually associated in cases which follow perforation. In instances where evidence of intra-uterine peritonitis is found, it is rarely possible to identify the causative organism. We have seen a case in which death occurred shortly after birth where a mass of peritoneal adhesions resulted apparently from the perforation of a duodenal ulcer before birth. Extensive adhesions may result from hemorrhage due to birth trauma.

**Pathology.**—In the early stages there is exudation of serum, fibrin, and leukocytes. When peritonitis results from perforation it is, as a rule, purulent from the outset, and the pus is foul. The amount of pus is proportionately larger than in adult cases. When the disease proves fatal in a few days, there is found an extensive exudation of fibrin, with the formation of small pockets containing pus among the coils of intestine. Occasionally there may be larger collections of pus in the peritoneal cavity. In cases which are not fatal in the early stage of generalized inflammation, the process becomes localized and results in the formation of a peritoneal abscess. This may occur whatever be the origin of the disease or the bacterial type of infection. The situation of the abscess depends somewhat upon the cause, but it is usually in one iliac fossa or in the pelvis. If left alone, such abscesses may open into the rectum, vagina, bladder, pelvis of the kidney, or externally—usually at the umbilicus. After the discharge of pus the cavity may contract and fill up by granulation, and the patient recover.

**Symptoms.**—The symptoms of acute peritonitis in older children, as in adults, are usually well marked and sufficiently characteristic to enable one to recognize the disease easily; but not so in the case of infants. In them the symptoms are often obscure, and the disease may be found at autopsy when not suspected during life. Although the conditions in which it occurs vary a good deal, the symptoms of acute peritonitis do not differ greatly whether it is due to a pneumococcus, a streptococcus or to other bacterial causes. The onset is usually abrupt, with fever and vomiting. As a rule, the temperature is high—from 103° to 105° F. Vomiting may occur only at the onset, but more often it continues; the vomitus is usually green or brownish. Older children complain of pain, which may be localized or general, and in younger ones this is indicated by crying and fretfulness. The abdomen very soon becomes swollen and tympanitic, this being one of the most constant features of the disease. The distention is generally uniform, but it may be irregular. There is tenderness on pressure and rebound tenderness. Rigidity of the abdominal wall may be marked; but the younger the patient, the less likely is this to be so. The pain causes the child to assume a fixed position and he cries if moved or disturbed. The posture is generally dorsal, with the thighs flexed. Flatus may or may not be passed. The bowels are in most cases sluggish, but diarrhea is by no means rare. The abdominal distention causes dyspnea and



thoracic breathing. There may be retention of urine or frequent micturition.

The general symptoms, almost from the beginning, are those of a serious disease. The pulse is small, rapid, and compressible. The prostration is great, from the very outset. In severe cases there may be hiccough, cold extremities, clammy perspiration, and collapse. The mind is usually clear. In infants there may be convulsions. A polymorphonuclear leukocytosis (15,000 to 25,000) is almost invariably present, but is wanting in some cases of the gravest type. Puncture of the peritoneum is a safe procedure in early cases before matting of the intestines has occurred, and is of the greatest help in diagnosis.

When peritonitis is secondary to pneumonia, especially when it comes late in the disease, there are frequently no new symptoms except vomiting and abdominal swelling. Even the vomiting may be wanting. The temperature is not usually high, 101° or 102° F. being common. The process may be general and the progress rapid, but it is more frequently slow and becomes localized.

In the most severe forms of general peritonitis the course is short and intense, and the disease goes on steadily from bad to worse until death occurs. In infants this is usually from the fourth to the sixth day. The very severe forms of general peritonitis in older children run the same rapid course. In other cases the course is slower, lasting a week or ten days. If the patient lives longer than this the case is more hopeful, because the process is more apt to be localized. The development of peritoneal abscess is indicated by the continuance of the temperature, which sometimes assumes a hectic type with chills and sweating. There are the local signs of an abdominal tumor.

**Prognosis.**—Acute general peritonitis, whatever its cause, is a very serious disease in childhood. Of 80 cases of all varieties under sixteen years of age, 69 per cent were fatal. In the newly born and in infancy the disease is usually fatal. In older children the outlook is not quite so bad, being the most favorable in the cases of primary pneumococcus peritonitis.

**Treatment.**—The question of operation is a matter for surgical judgment with each individual patient. In many cases where there is no removable focus such as a ruptured appendix, it is wise to defer operation in order to permit spontaneous walling-off of the infection.

Medical treatment is only symptomatic. The bowel must be put at rest by withholding food and for a time even water by mouth. Nutrition may be maintained by parenteral administration of glucose and salt solution and by transfusion. Should the process begin to abate, feeding by mouth may be cautiously commenced. This is always a difficult matter on account of the strong tendency to vomit, which is not easily controlled by gastric lavage. Cathartics are contraindicated, as they inevitably stir up the inflammatory process. Tympanites, often severe and painful, is controlled mainly by starvation and by irrigation of the large bowel. Turpentine stupes may aid in its relief, but in general local applications of any sort to the abdominal wall play little part either in the control of symptoms or in the course of the infection. Opiates may mask important symptoms and increase distention, but in some cases one is forced to resort to them for the control of pain.



## CHRONIC (NONTUBERCULOUS) PERITONITIS

Peritonitis may occur in fetal life with the production of extensive adhesions, which may interfere with the development of the intestine and result in various malformations. The cause of the peritonitis is quite unknown. There is no evidence that syphilis is responsible.

Chronic peritonitis may follow the acute form, in which there are left adhesions which slowly increase owing to the production of new connective tissue. Such cases are sometimes chronic from the beginning.

The peritoneal abscesses which follow the suppurative form may run a chronic course. Chronic localized peritonitis may occur in connection with disease of any of the organs covered by the peritoneum.

**Chronic Peritonitis with Ascites.**—The literature contains a number of references to a chronic nontuberculous form of peritonitis with ascites, which runs a benign course. Most of these reports were before the days of modern bacteriology; hence the nature of this condition remains obscure. In all probability many of these instances were unrecognized tuberculous infections.

## ASCITES

Ascites consists in an accumulation of fluid, usually clear serum, in the general peritoneal cavity. It is a symptom of the various forms of peritonitis, especially the chronic varieties described in the preceding pages. It may be due also to portal obstruction from cirrhosis of the liver, or pressure upon the portal vein by peritoneal adhesions or enlarged lymph nodes. It is occasionally seen in all forms of abdominal tumors. Ascites may occur in general dropsy from cardiac disease, or from any condition causing pressure upon the inferior vena cava. Its presence in chronic heart disease without general anasarca is suggestive of adhesive pericarditis. It is also seen in the general dropsy of renal disease and nutritional edema. A moderate amount of ascites is often met with in extreme anemia or leukemia.

Small accumulations of fluid in the peritoneal cavity are difficult of detection. Large amounts are generally easily made out. There is a uniform smooth distention of the abdomen and dilatation of the superficial veins, especially about the umbilicus. There is a fluid wave, and the area of dullness shifts with change of position.

Cysts of the omentum or mesentery are to be distinguished from ascites. They usually have been present from birth and cause no disturbance except from pressure. The fluid withdrawn from them, especially on the second tapping, may contain blood as they not infrequently communicate with veins. Rarely the distention of a hydronephrosis may be difficult to distinguish from ascites.

In cases of chronic intestinal indigestion accumulations of fluid or semifluid feces in the enlarged colon often give signs which can hardly be distinguished from those due to a moderate amount of fluid in the peritoneal cavity.

The prognosis and treatment of ascites will depend upon its cause. Removal of the fluid by paracentesis for control of symptoms seldom yields more than temporary benefit, since reaccumulation takes place, as a rule, within less than a week. A few of the chronic cases do well on diuretics.



**Chylous Ascites.**—This term is applied to certain cases in which the abdominal fluid contains fat. The color may be milky-white or light brown, and the fluid, after standing, may have at its surface a thick, creamy layer. The amount of fat present has been as high as 5 per cent. This condition is rare in childhood. In the cases which have thus far come to autopsy there has usually been found chronic peritonitis, sometimes simple, sometimes tuberculous. In most of them there has been obstruction with dilatation of the lymph vessels; in some, however, these have been empty and no obstruction could be found. In some of the cases the ascites has been due to a wound of the thoracic duct. The amount of fluid is frequently very large. The prognosis is usually bad, although recovery following laparotomy has been reported.

### SUBPHRENIC ABSCESS

In the group of cases of localized peritonitis or peritoneal abscess must be included subphrenic abscess. This is a rare condition in childhood, and consists in an accumulation of pus just beneath the diaphragm and above the liver. Its cause may be either in the thorax or in the abdomen. It may complicate acute pneumonia, usually of the right lower lobe, by direct extension of infection through the lymph channels or perforation of the diaphragm by an empyema. Sometimes it has been associated with tuberculous cavitation. In the abdomen it results from the extension of some focus of suppuration, such as an abscess around the appendix or abscess of the liver. The accumulation of pus is sometimes very great, so that the diaphragm is crowded high into the thorax.

The symptoms and physical signs closely resemble those of empyema, and most of the cases have been operated upon with the belief that the surgeon was dealing with empyema. Subphrenic abscesses may contain air; they are then likely to be mistaken for pneumothorax. The x-ray frequently assists in the diagnosis, showing air or a mass beneath the diaphragm. These abscesses require incision and drainage like other forms of peritoneal abscess.

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## CHAPTER XXXV

### DISEASES OF THE ABDOMINAL PARIETES

**Umbilical Granuloma.**—This is nothing more than a mass of exuberant granulations persisting after the cord has fallen off. It is generally about the size of a pea—sometimes larger—bleeds readily, and has a thin, purulent discharge. If untreated it may remain for some weeks, eventually becoming covered with epithelium and leaving a pedunculated cicatrix. It is promptly cured by the application of any simple astringent, such as powdered alum or silver nitrate. Larger polypoid masses may be tied with a silk ligature at the base and snipped off with scissors.

**Cellulitis of the Umbilical Region.**—It is not uncommon for infection to gain entrance through the open umbilical wound at birth or shortly after and to set up inflammation in the surrounding tissues. Erysipelas sometimes starts here. The local infection should be treated symptomatically. The umbilical wound may be the portal of entry of a general systemic infection even when no local inflammation is evident.

**Mucous Polyp—Umbilical Fistula.**—These terms are used synonymously to describe an umbilical tumor covered with mucous membrane which is similar in structure to that of the small intestine. It is usually associated with an umbilical fistula. This tumor is formed by a prolapse at the navel of the mucous membrane of Meckel's diverticulum. This diverticulum is the remains of the omphalomesenteric duct. When it is present in infants, it is found in various stages of development. Most frequently there is a blind pouch a few inches long given off from the lower part of the ileum. In other cases it may remain patent quite to the umbilicus, causing a fecal fistula (Fig. 45 A). As the intestine below it is generally normal, this fistula may persist for months or even years, giving rise to no symptoms except a slight fecal discharge from the umbilicus. In certain cases intestinal worms have been discharged through it. It may close spontaneously or be closed by operation.

A prolapse of the mucous membrane lining the diverticulum produces an umbilical tumor with a fistula at its summit (Fig. 45 B). This is the most common form. A cross section shows under the microscope the structure of the intestinal mucous membrane both as an external covering and lining of the fistulous tract. The prolapse may involve not only the mucous membrane but the entire intestinal wall. There then exists a conical tumor with a fistula which has but one external opening, but at a short distance from the surface it bifurcates, one branch leading upward and one downward (Fig. 45 C). A continuation of the prolapse gives a broad pedunculated tumor (Fig. 45 D), which may reach the size of an orange. Its covering is the same as in the other forms. It may contain several coils of intestine. In this form there are usually two fistulous openings (*a*, *b*) which communicate with the intestine.



In all of these cases the tumor is smooth, irreducible, of a rosy pink color, and from its surface there oozes a mucous discharge. Microscopical examination shows the external covering to be the same in structure as the intestinal mucous membrane. These tumors are generally small, varying in size from a pea to a small cherry, but they may be very much larger. A fecal fistula usually, but not invariably, coexists. In the condition represented in Figure 45 B, it is easy to see how an obliteration of the fistula may occur. The small tumors are readily cured by ligature. The larger ones are usually associated with other serious malformations of the intestines, which make the outlook bad in almost every instance.

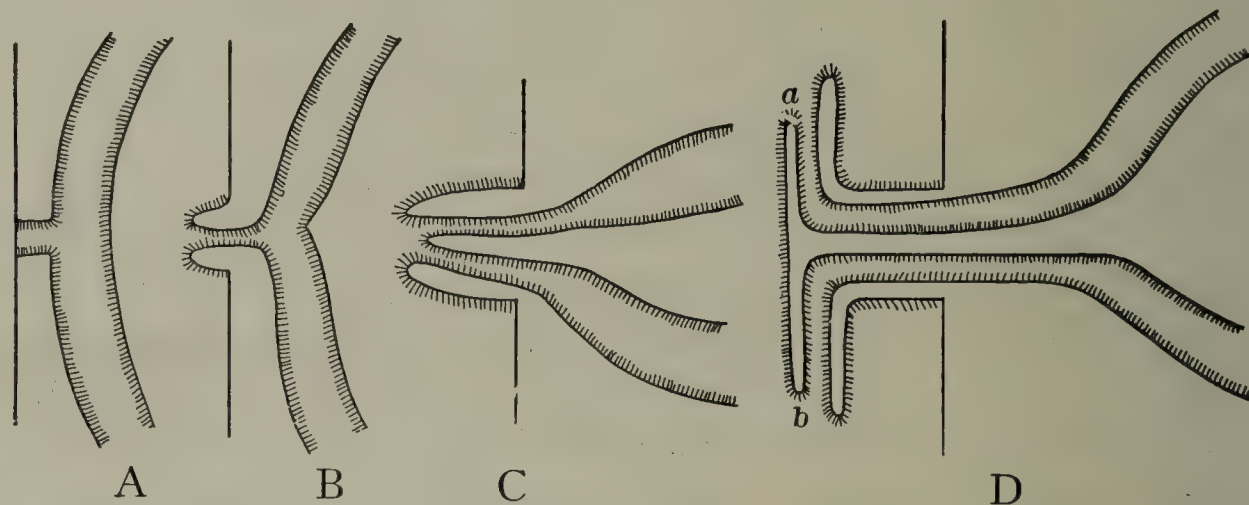


FIG. 45.—UMBILICAL FISTULA AND TUMORS PRODUCED BY PROLAPSE OF MECKEL'S DIVERTICULUM (BARTH).

**Fistulae and Cysts of the Urachus.**—These are described under Diseases of the Urinary Tract (page 659).

**Hernia into the Umbilical Cord.**—This is a rare congenital condition of a serious nature. It is due to a fetal defect in closure of the umbilical ring, and varies in size from a small protrusion to complete eventration in which nearly all the abdominal organs are outside the body. Many cases in which only intestinal coils are contained in the sac, though the tumor is quite large, are amenable to surgical treatment, which should be instituted at once. In the very large ones the prognosis is bad.

**Umbilical Hernia.**—The common umbilical hernia is quite a different condition, and, while a source of much annoyance, it is rarely serious. It is more common in females than in males, and occurs especially in those who are poorly nourished and rachitic. The tumor is usually from one-fourth to one-half an inch (about one to two centimeters) in diameter and can easily be reduced; on careful palpation a small hernial ring is usually felt. The protrusion usually contains omentum, but sometimes—especially with larger masses and a larger ring—there is local tympany and a gurgling on reduction. Sometimes the hernia may be very large; rarely, too, strangulation takes place. The diagnosis is simple except in the case of small tumors, when a redundancy of the skin itself may easily be mistaken for hernia. The majority of small umbilical herniae disappear spontaneously within a few months. Even fairly large ones usually yield to simple mechanical measures; the skin of the umbilical region should be folded into a longitudinal groove in which the umbilicus is hidden, and should be held thus by a band of adhesive



tape at least two inches wide and long enough to reach laterally to the posterior axillary line on each side. The tissues serve in this way as a compression pad. Strapping should not be applied unless the umbilicus is absolutely dry and healthy, and the adhesive must be removed every week or two for inspection of the skin and reapplication at a different angle if there has been any dermatitis. If with such measures the hernia has not been cured by the end of the first year, operation may be necessary. In hernia associated with rickets, the improvement in

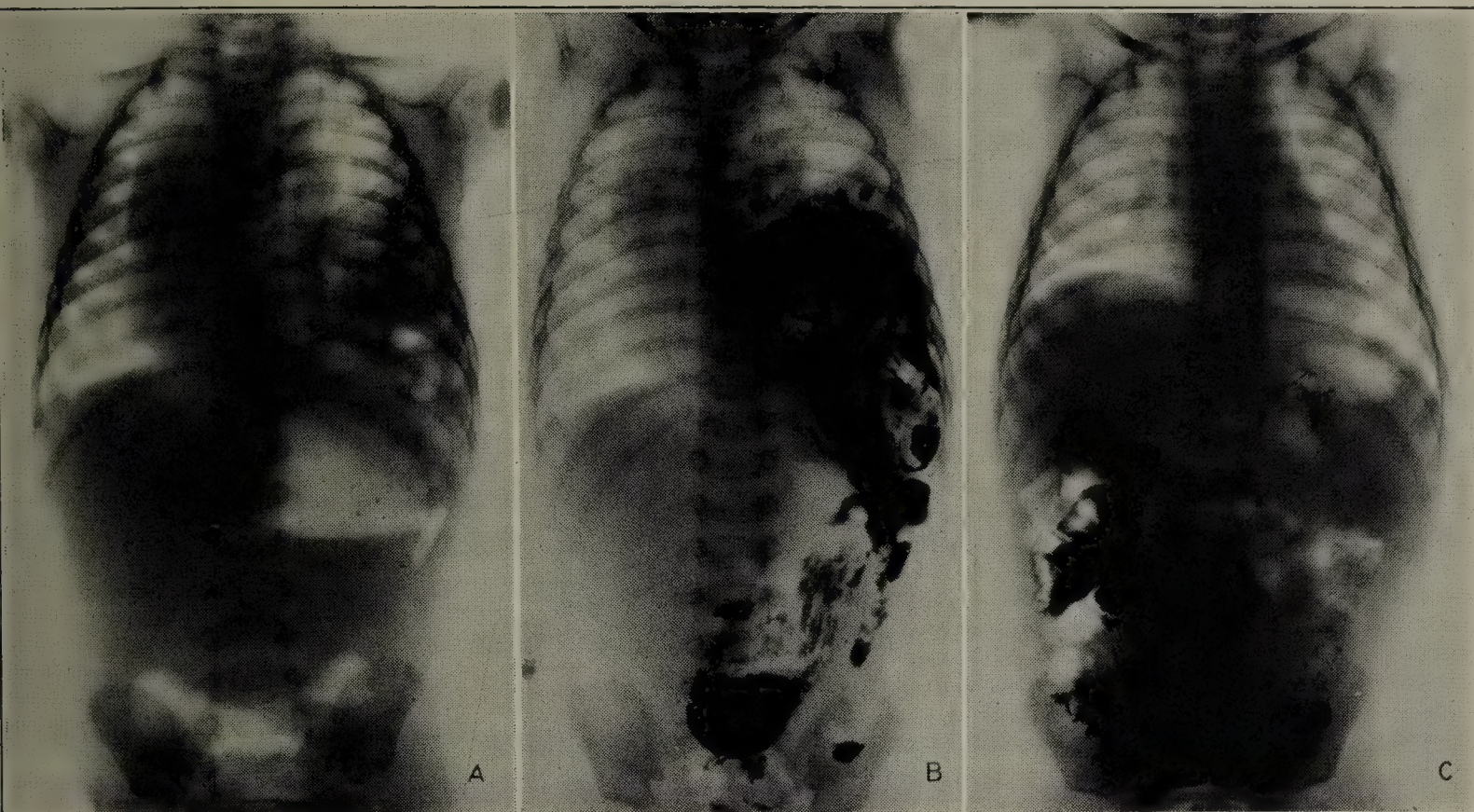


FIG. 46.—DIAPHRAGMATIC HERNIA OF THE LEFT SIDE.

Infant four and one-half months old. A, Condition before operation. B, Same, three hours after barium meal, showing coils of small intestine and colon in left thoracic cavity. C, six weeks after operation and five hours after barium meal.

Paul N. (B. H. 269691) age four and one-half months, was well until three and one-half months of age when he suddenly screamed with pain, went into collapse and had a convulsion. He was partly relieved by a warm bath, but continued to cry out for about eight hours when he seemed suddenly to be completely relieved. Two days later he had a shorter and milder attack. For the next five weeks he had loss of appetite and a varying amount of pain; this was always relieved by enema. On admission, weight 15 pounds; exaggerated respiratory movements; dull tympany in left chest with gurgling and diminished breath sounds on auscultation; heart pushed to right; liver margin depressed. Roentgenograms (A and B) showed coils of intestine in left pleural cavity, with some evidence of functioning diaphragm on the left. At operation (abdominal approach, Dr. E. J. Donovan), a defect of the left posterior leaflet of the diaphragm was found, with an opening 3 centimeters in diameter through which protruded a large part of the small intestine, some of the colon, and the spleen. These were replaced in the abdominal cavity and the defect sutured. He made a satisfactory recovery (C).

muscle tone accompanying successful antirachitic treatment appears to accelerate the healing of the hernia. It is needless, indeed unwise, to limit the activity of infants with hernia, since the improvement in the general musculature resulting from normal exercise plays an appreciable part in the cure.

**Inguinal Hernia.**—This is much more common in boys than in girls. The great majority are of the indirect type, and in many of those appearing early in life the peritoneal cavity is continuous with the tunica vaginalis of the testicle (congenital form). The condition is often bilateral. Incarceration and strangula-



tion are relatively uncommon. As with umbilical hernia, many cases heal spontaneously during the course of the first year; others respond to simple mechanical measures, to some form of truss. Perhaps the majority of cases persisting after the end of the second year will eventually come to operation.

Any form of hernia, umbilical or inguinal, may be aggravated during an attack of whooping cough or, once cured, may reappear.

**Diaphragmatic Hernia.**—This is due to a congenital deficiency in the diaphragm, which is usually on the left side. Of 108 cases collected by Livingston, 83 were on the left side, 18 on the right, 4 were central, 2 were double, and in 1 the diaphragm was absent. With small openings only a single coil of intestine, with large ones a considerable part of the abdominal contents, may be found in the thorax. This causes displacement of the heart, usually to the right side, prevents the full expansion of the left lung, and if the deformity occurs early in intra-uterine life the lung may remain rudimentary. If a large deficiency exists, infants may live but a few hours; with smaller ones, life may be prolonged indefinitely.

The symptoms noticed soon after birth are usually cyanosis, rapid respiration, a sunken abdomen, an overdistended chest, and dyspnea. Children often live but a few hours. In those who survive a longer time dyspnea is generally the most prominent symptom. It may be constant, or occur at intervals in severe paroxysms, or there may be severe attacks of cyanosis produced by an accumulation of gas in the stomach or the thoracic part of the intestine. Other symptoms may at times suggest intestinal obstruction. The physical signs vary much from time to time. Sometimes those of pneumothorax are present; at others there is so much dulness with the feeble respiratory sounds, as to suggest fluid. The signs are usually upon the left side, with displacement of the heart to the right. A positive diagnosis can often be made by means of the x-ray after administration of bismuth. A number of patients have been cured by operation.

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## SECTION VI

### *DISEASES OF THE MOUTH, NOSE, THROAT AND EARS*

#### CHAPTER XXXVI

#### DISEASES OF THE MOUTH

#### MALFORMATIONS

**Harelip.**—This is one of the most frequent congenital deformities. It is caused by an incomplete fusion of the central process with one or both of the lateral processes from which the upper half of the face is developed. The fissure is never in the midline, but is usually just beneath the center of the nostril. There may be only a slight indentation of the lip, or the fissure may extend to the nostril. Both single or double harelip—more frequently the latter—may be accompanied by cleft palate.

The problem of nutrition is often a matter of great difficulty in these infants. Except in the mild cases sucking is impossible since the passage of air through the fissure prevents the formation of the necessary vacuum. In this event the mother's milk should be pumped and the child fed with a medicine dropper or by gavage until operation can be performed.

Harelip should be operated upon as soon as the condition of the child will permit. With a vigorous child it may be done in the first two weeks of life. With feeble or premature children it may be wise to postpone it. One should remember, however, that it does not necessarily follow that the condition of such children will be better at a later time. Many die of malnutrition even with the best of care. Thrush is a common complication and is a serious menace to the success of the operation.

The operative procedures employed are described in works on surgery. The results are usually satisfactory. It is wise to continue feeding by medicine dropper or by gavage for several days following operation.

**Cleft Palate.**—This is often associated with harelip, but may occur without it. All degrees are seen. The fissure may involve only the soft palate, or it may extend to the nose, involving the entire hard palate as well. It may be unilateral or bilateral. There may be partial or complete lack of development of the vomer and nasal septum. When these are entirely absent there is found one large defect in the midline of the roof of the mouth.

The mechanical disadvantages in nursing, even more than in the case of harelip, often prevent these infants from establishing and maintaining an adequate breast milk supply. They can be fed with a dropper as described above, but it is not uncommon for them to expel milk, however given, through the nose during



the act of swallowing. When harelip and cleft palate are combined, the ease with which infection enters the mouth leads often to marked hypertrophy of the tonsils and adenoids.

A variety of plastic operations for this condition have been devised. In some the defect is bridged by mucous membrane; in others the two maxillae are brought together by traction; in still others when the fissure is unilateral and the vomer and septum are well developed the septum is severed and its lower half brought down to close the gap. The results are, however, far less satisfactory than in the case of harelip. Even if the palate is successfully bridged there are other complications which may remain. The newly formed soft palate may not function properly, and unless complete closure between the oral and nasal cavities is possible the characteristic speech defect remains. Secondary narrowing of the maxillary arch following operation may lead to dental malocclusion or there may be a depression of the nose and alteration of the facial contour.

No general rules in regard to the time of operation can be given. When the defect is small and one of the simpler operations can be employed, it is advisable to do this in the first few weeks, at the time the harelip operation is performed. In other instances postponement is advisable, but if operation is deferred beyond the age when speech begins to be developed, the characteristic speech defect may be difficult to eradicate, even when the mechanics of the palate appear to have been restored to normal. In the most extreme cases, surgery offers little hope of improvement. A common cause of failure of plastic operations is chronic disease of the paranasal sinuses. If a chronic discharging sinus is present, this should first be cleared up before any operative procedure is attempted. Much can be done to correct speech defects and prevent malocclusion by various dental appliances. On this account dental advice as well as surgical should be sought at an early date.

**Hypertrophy of the Tongue.**—This is usually due to abnormality of the lymphatics, and is to be regarded as a lymphangioma. The tongue may reach an enormous size, so that it is impossible for it to be contained within the cavity of the mouth, and it may thus interfere with nursing, deglutition, and even with respiration. A certain amount of improvement may take place spontaneously, as in lymphangiomata of other regions, but the severe cases require operation. Cases like the above are to be distinguished from those of enlargement of the tongue seen in sporadic cretinism. In this disease the tongue is considerably enlarged and may protrude slightly from the mouth, but it is rarely, if ever, large enough to cause other symptoms.

**Tongue-tie.**—This deformity is due to such a shortening of the frenum that it is impossible to protrude the tongue to a normal extent. Tongue-tie may interfere with articulation, and even with sucking. It is common for mothers to think the child tongue-tied when the frenum is of normal length. The treatment consists in liberating the tongue by dividing the frenum with scissors; but operative interference is very infrequently required. If the tongue can be protruded beyond the lips, no treatment is necessary.

**Geographical Tongue.**—This is characterized by the appearance upon the dorsum or margin of the tongue, of circular, elliptical, or crescentic red patches, with gray margins which are slightly elevated. The gray margins are apparently



due to thickening of the epithelial layer and the red areas to desquamation of the epithelium. It is quite a common condition, and is probably congenital. As usually seen, there exist upon the tongue from two to four of these red patches surrounded by a gray border, which is one or two millimeters wide, and slightly elevated. From day to day the configuration of the patches changes; the gray lines advance across the tongue from side to side, or from base to tip, disappearing as they reach the border or the extremity. They are followed by the red patches, and as the old ones fade away new ones form and run the same course. Only the epithelium is involved, the deeper structures being unaffected. The duration of the disease is indefinite; it usually lasts for years. The cause is unknown. It is not accompanied by pain, salivation, or by other symptoms of stomatitis, and is of little practical importance. Treatment is unnecessary.

## INFLAMMATIONS OF THE MOUTH

**Herpes Simplex.**—Herpes simplex is an exceedingly common affection in children, occurring in acute febrile diseases, particularly pneumonia and meningitis. It is the familiar “fever sore” or “coldsore” of domestic medicine. The vesicles appear singly or in groups; subsequently they rupture with the formation of crusts. The herpetic lesions are usually confined to the lips, but they may occur on the buccal mucosa, on the hard palate or in other locations over the surface of the body (*herpes facialis*, *herpes genitalis*, etc.). Unlike herpes zoster, the distribution of the lesions bears no relation to that of the sensory nerves. The disease is of little clinical importance, for it heals without treatment. Not infrequently, however, there is a disposition to pick at the vesicles, which may result in their becoming secondarily infected. Restraint may be necessary to prevent this.

The etiology of this form of herpes was formerly entirely obscure. It has been recently shown, however, that a filtrable virus is constantly present in the herpetic vesicles. This same virus is often found in normal human saliva. It is extremely pathogenic for rabbits, producing encephalitis in these animals. The herpes virus is not present in the lesions of herpes zoster, which appears to be an entirely different disease.

It would thus seem that the herpes virus is usually nonpathogenic for man. Under exceptional conditions of lowered resistance it may give rise to the herpetic lesions. It is believed by some that this virus is responsible for epidemic encephalitis; conclusive evidence for this belief is, however, wanting.

**Stomatitis.**—Specific lesions in the mouth are found with many of the infectious diseases, with deficiency diseases like scurvy and pellagra, and in certain types of poisoning with inorganic substances. In addition to these there is a group of inflammatory processes which are localized almost entirely to the mouth. The etiology of these is in some instances well known and in others quite obscure.

**Infectious Diseases.**—The characteristic enanthem of *measles* (Koplik’s spots) is described elsewhere. In *scarlet fever*, the hypertrophied papillae showing through a heavily coated tongue give rise to the typical “strawberry tongue.” In *varicella* vesicles are occasionally, ulcers quite frequently, found on the buccal mucous membrane. *Diphtheria* may involve the mucous membrane of the mouth, the lips or the tongue. It is seen, however, only in the severest cases, accompanied by extensive



involvement of the pharynx and tonsils. The labial fissures and mucous patches in the mouth seen in *congenital syphilis* are more fully described under that disease. In cases of acquired syphilis the primary sore may be seen upon the lip, the tongue, or the tonsil.

*Toxic Stomatitis.*—Most of the drugs which commonly give rise to skin eruptions fail to cause oral lesions, a point which is often of great diagnostic assistance. Lesions in the mouth are, however, found in cases of poisoning with certain heavy metals. The black “lead line” in chronic *lead* poisoning is situated in the margin of the gums. It is due to the deposition of lead sulphide. A very similar line is seen in *bismuth* poisoning, but this latter condition is often accompanied by a diffuse stomatitis and by extensive areas of pigmentation on the tongue or anywhere in the buccal mucosa. Poisoning with *mercury* gives rise to the condition known as “ptyalism.” There is a diffuse catarrhal stomatitis with red, swollen gums which bleed easily. There is a metallic taste in the mouth, toothache and profuse salivation. In severe cases there may be ulcers upon the tongue, cheek and palate; the breath is foul, the teeth loosen and fall out, and there may be necrosis of the jaw. These severe manifestations are usually due to a secondary infection with Vincent’s spirillum which occurs not infrequently. A similar condition may occur in chronic *phosphorus* poisoning.

*Stomatitis in Deficiency Diseases.*—In *pellagra* lesions are found on the tongue and the mucous membranes of the mouth. The tongue is usually inflamed and swollen; the papillae are hypertrophied. It may be coated in the center, with clear edges. There may be a diffuse stomatitis with areas of ulceration. The swollen, hemorrhagic gums of *scurvy* are fully described under that disease.

*Catarrhal Stomatitis.*—This may complicate many general diseases, as just mentioned, or it may occur independently. It may result from chemical, mechanical, or thermal trauma. It frequently occurs during dentition. The mucous membrane is intensely congested and bleeds easily; ulceration may occur in certain areas. There is considerable pain as shown by fretfulness and disinclination to take food; infants, though evidently hungry, either refuse food altogether or cease taking it after a few moments. Salivation is very marked, saliva pouring from the lips and often drenching the clothing. Glossitis is usually present. The regional lymph nodes are enlarged and tender. Constitutional disturbance is not often marked, although there may be digestive disturbance. The course is usually short.

Treatment consists in the application of cold; sucking cracked ice appears to give relief. Food should be given cold; if refused, feeding by gavage may be resorted to. Bland alkaline mouth washes are of value. Astringents may be employed when ulceration is present.

A severe form of *stomatitis due to the gonococcus* has been observed in newly born infants, when infection has occurred from the mother at the time of birth. Other evidences of gonococcus infection, especially ophthalmia, are usually present. The inflammation is characterized by the formation of yellowish-white plaques of exudate upon the tongue or hard palate. The gonococcus can be recovered from this exudate. It is probable that trauma plays a part in producing this lesion. This condition seldom lasts more than a week or ten days. Treatment consists in fre-



quent irrigation of the mouth with boric acid and in the application of some anti-septic like mercurochrome.

*Aphthous Stomatitis*.—Very little is known of the etiology of this condition. It appears at all ages, in well nourished children as well as those suffering from nutritional disturbance. The term *herpetic stomatitis* has been applied since it is probable that the cause is identical with that of herpes simplex. The lesions occur singly or in groups; they may be found upon any part of the mucous membrane of the mouth, most frequently on the cheek opposite prominences of the teeth. There is first of all a hyperemic area, sometimes with a minute vesicle in its center. This often ruptures at an early stage. In any case necrosis occurs at the center of the lesion with the production of a yellow fibrinous exudate (see Plate III, opposite page 916). There may be loss of appetite, for food is likely to induce pain. Other constitutional symptoms are seldom noticeable. The duration of these ulcers is seldom longer than a week unless the general health is poor. Spontaneous healing takes place without cicatrization.

The application of astringents such as burnt alum, or cauterization of the ulcer with silver nitrate, is said to shorten the duration. In our experience the use of oxidizing agents, as described under Ulcerative Stomatitis, has been quite as effective.

**Ulcer of the Frenum**.—Friction against the sharp edges of the lower central incisors frequently causes an ulcer of the frenum in infants. We have never seen it in older children. It usually occurs in pertussis, but is seen in other conditions. In some it appears to be produced by friction of the teeth during nursing from the breast or bottle. It is more often seen in children who are delicate or cachectic than in those who are healthy and well nourished. The ulcer may be confined to the frenum, or it may extend quite deeply into the tongue. It is usually about half a centimeter in diameter, and of a yellowish-gray color. When associated with whooping cough it usually persists as long as the spasms recur. In other cases, the ulcer may be touched with alum or silver nitrate and the child fed by dropper or gavage for several days.

**Ulceration of the Hard Palate—Bednar's Aphthae**.—This condition, usually seen in very young infants, may occur in any child suffering from extreme malnutrition. The primary cause is often an injury inflicted in cleansing the mouth. In other cases it is due to the friction of the rubber nipple, or some other object which the child is allowed to suck. In still others it is apparently produced by the habit of tongue-sucking. The appearances are quite characteristic: there is found, rather far back upon the hard palate, usually in the mid-line, a superficial ulcer, from a fourth to a half inch in diameter. It is not uncommon to see two aphthae symmetrically situated, each above and somewhat mesial to the tonsillar fossa. There is no surrounding zone of inflammation, and as far as one can tell the condition is not particularly painful. In children suffering from malnutrition these ulcers are very intractable, and in many instances their cure is practically impossible. It is therefore especially important to prevent, if possible, their formation, by care in cleansing the mouth, and in avoiding the other causes referred to. When ulcers have formed they should be treated as in cases of aphthous stomatitis.



## THRUSH

Thrush is a parasitic form of stomatitis characterized by the appearance upon the mucous membrane, usually of the tongue or the cheeks, of small white flakes or larger patches. It is common in young infants, and in all the protracted exhausting diseases of early life.

**Etiology.**—The vegetable parasite which produces thrush, it is now generally agreed, is the *Saccharomyces albicans*, not the *Oidium albicans*. If a little of the exudate from the mouth is placed upon a slide and a drop of 10 per cent potassium hydroxide solution added, the structure of the fungus is readily seen. The spores of this fungus are of very common occurrence in the atmosphere. It is difficult or impossible for thrush to develop upon a healthy mucous membrane. Its growth is favored by slight abrasions and want of cleanliness. The nature of the process which it produces is in all probability a sugar fermentation, the acid reaction of the mouth being the result of the growth rather than its cause. Infection may come from another patient by means of a rubber nipple or a cloth which has been used for the infected mouth, from the nipple of the nurse, or directly from the air. It is frequent in the first two or three months of life, also in protracted wasting diseases, dysentery, malnutrition, typhoid, tuberculosis, etc. It is very common in infants suffering from harelip or any other deformity of the mouth. The disease is a common one in foundling asylums, in all places where many young infants are crowded together, and where cleanliness of mouths, bottles, etc., is neglected.

**Pathology.**—The spores lodge between the epithelial cells and gradually separate the different layers. This occurs before the formation of the white pellicle. Later the disease spreads on the surface of the mucous membrane, and also penetrates the deeper structures. It may invade the blood vessels and cause thrombosis or even be carried to distant parts. Although the *Saccharomyces albicans* is commonly found upon squamous epithelium, its growth is not confined to it. It usually begins at many distinct points upon the mucous membrane, and gradually spreads until coalescence takes place; a continuous membrane may be thus formed.

The usual seat is the margin of the tongue, the inside of the lips and cheeks, and the hard palate, but not infrequently it involves the pillars of the fauces, and the entire pharynx. Further extension than this is rare, although the esophagus, the stomach, the intestines, and even the skin may be invaded. Cases involving the esophagus and the stomach appear from reports to be much more common in Europe than in this country. In a few cases in the Babies' Hospital the *Saccharomyces albicans* has been found in the lungs of infants suffering from bronchopneumonia. There are several reported cases of general blood infection from this organism.

**Symptoms.**—The essential symptoms of thrush are the appearance upon the mucous membrane of the mouth—usually beginning upon the tongue or the inner surface of the cheek—of small white flakes which resemble deposits of coagulated milk, but which differ from them in the fact that they cannot be wiped off. If forcibly removed, they usually leave a number of bleeding points. There may be only a few scattered patches, or the mouth and pharynx may be covered. The mouth is generally dry and the tongue coated; there may be some difficulty in



swallowing. The other symptoms depend upon the conditions with which the thrush is associated.

**Diagnosis.**—This is rarely difficult. When existing upon the pharynx and fauces thrush has been confounded with diphtheria, although this mistake can hardly be made if all the facts of the case are taken into consideration—the age of the patient, the involvement of the lips and tongue, the dry mouth, the absence of glandular enlargement, etc. In any case of doubt the examination of the deposit under the microscope usually reveals its true nature. In cultures made on Löffler's medium, the large spores of the fungus are easily recognized.

**Prognosis.**—Thrush is rarely in itself a dangerous disease, but in a feeble and delicate infant, or in one with harelip or cleft palate, it may be a serious complication. With proper treatment most of the cases involving only the mouth are readily cured.

**Treatment.**—Thrush may usually be prevented by due attention to cleanliness of the mouth, rubber nipples, bottles, cloths, etc. In infants with deformities of the mouth, and in institutions, it frequently develops despite all precautions. In treatment the essential things are cleanliness, and the use of some mild antiseptic. The most effective one is gentian violet. A 1 per cent aqueous solution may be applied on a swab several times a day, the white deposit being removed before the dye is applied. With such treatment the disease seldom persists more than two or three days. In the absence of treatment it may last several weeks. At times the disease seems to be prolonged by the irritation of the rubber nipple. In such cases it may be of advantage to feed by medicine dropper for a few days.

## VINCENT'S INFECTION

(ULCERATIVE STOMATITIS; ULCEROMEMBRANOUS STOMATITIS; TRENCH MOUTH;  
ULCEROMEMBRANOUS TONSILLITIS; VINCENT'S ANGINA)

**Etiology.**—Under this heading are considered a group of infections of the oral cavity due to a specific organism first described by Vincent. This organism may produce infections of the lungs and bronchi or of the other mucous membranes of the body, but in the large majority of instances the lesions are confined to the mouth. Vincent's bacillus or *Bacillus fusiformis*, an obligatory anaerobe, is a pleomorphic organism. In cultures only the bacillary form is seen.<sup>1</sup> When growing on living tissue, however, a spirillum is always associated with the bacillus. It has been definitely shown that the spirillum is a degenerative form of the bacillus.

Vincent's bacillus can be detected in many mouths where no infection is present. In the presence of infection, however, these organisms are very numerous and may be found in almost pure culture. It is probable that some factor which lowers resistance is necessary for infection to occur. This may be general or local. The disease is common in institutions and in dispensary and hospital patients, where food and hygienic conditions have been poor; it is rarely seen in private practice. Its severe forms are seldom seen except as complications of general diseases, particularly measles, scarlet fever and typhoid fever. Local conditions which lower resistance are quite as important as the foregoing. It is common for infection to

<sup>1</sup> It is a thin gram-negative bacillus, from 6 to 12  $\mu$  in length, with pointed ends.



start in the gums adjoining a carious tooth. It may complicate the oral lesions of scurvy or of poisoning with heavy metals, particularly mercury, lead and phosphorus. The disease is only slightly contagious.

**Symptoms.**—The disease may begin in any part of the mouth. Not infrequently it is first seen upon the tonsil (Vincent's angina). A favorite site is the outer surface of the gum opposite a molar tooth. Multiple lesions are often found. The typical lesion consists of a dirty yellowish-gray patch, on removal of which bleeding takes place. The mucosa in the vicinity of the necrotic area is deeply congested. The infection shows a marked tendency to spread, particularly along the gingival margins, where a line of ulceration may form. The swelling may be so great that the teeth are almost covered. In neglected cases the disease may extend into the alveolar sockets, the teeth loosening and falling out. This may be followed by necrosis of the jaw or by noma. Such severe cases are met with chiefly in institutions and then generally follow measles or scarlet fever.

The first symptom usually noted is offensive breath. Salivation may be very profuse. There is a disinclination to take food, for the diseased parts are painful to the touch. The regional lymph nodes are enlarged and tender but do not suppurate. Constitutional symptoms are usually wanting; we have, however, seen several cases in which there was hyperpyrexia. A profound secondary anemia may develop in prolonged cases.

The diagnosis seldom offers difficulties. When the lesions are confined to the tonsil they may well be mistaken for diphtheria. The characteristic appearance of the smear in Vincent's infection and the failure of diphtheria bacilli to grow out on culture will settle the question.

The course of Vincent's infection is variable, and is greatly influenced by treatment. Neglected cases may persist for weeks. When the process has involved the roots of the teeth or the jaw it is more resistant to treatment. Although the prognosis is usually good, it should not be forgotten that the malignant gangrenous form may develop. For this reason it is a mistake to regard the disease lightly. Every case, no matter how mild it may appear, should be thoroughly treated.

**Treatment.**—The two most effective measures for combating this infection are local cleanliness and the use of oxidizing agents. Both of them tend to prevent the anaerobic conditions which favor the growth of Vincent's bacillus. Removal of the shreds of necrotic tissue and application of an oxidizing agent should be carried out several times a day. In resistant cases it may be necessary to do this every two or three hours day and night. The oxidizing agents commonly employed are hydrogen peroxide or a saturated solution of potassium chlorate which may be applied on swabs, and sodium perborate which is applied in powdered form. This last is in our opinion the most effective remedy. Arsenical preparations have been widely used in this condition both locally and internally, largely because of the spirochetal form which Vincent's bacillus tends to assume when growing in the body. We have not been convinced of their value; certainly they are not to be compared with agents like sodium perborate. Unless the infection is deep-seated the response to therapy is usually prompt. Marked improvement can be seen within forty-eight hours and often earlier. When the roots of the teeth are involved and the teeth have become loosened they should be promptly extracted.



It should not be forgotten that Vincent's infection often depends upon some generalized disorder. In particular the presence of metallic poisoning or of scurvy should not be overlooked.

## NOMA

(GANGRENOUS STOMATITIS; CANCRUM OVIS)

The term noma is used to denote a process of rapidly spreading gangrene involving the mucous membranes or mucocutaneous orifices. The most frequent situation is the mouth, but the disease may affect the nose, external auditory canal, vulva, prepuce, or anus. It is a rare disease and usually terminates fatally.

**Etiology.**—It is now generally accepted that this is a malignant form of infection produced by Vincent's bacillus. A great variety of organisms are present in the superficial sloughs, but in the areas of beginning necrosis only fusiform bacilli and spiral forms can be detected.

The malignant nature of the process appears to depend upon the feeble resistance of the patient, usually the result of some acute disease. Whether the organism itself is increased in virulence has not been ascertained.

Noma is seldom seen outside of institutions for children. It occurs in children of poor general condition and usually follows infectious diseases, most frequently measles and next to this scarlet fever, typhoid fever and pertussis. The parts attacked are usually the seat of previous local disease. In the mouth it may be preceded by a benign Vincent's infection or by other forms of stomatitis; in the auditory canal by a chronic otitis media. The disease is apparently more contagious than the benign forms of Vincent's infection. We know of an instance in which 5 cases developed in a single ward, all beginning in the auditory canal, apparently produced by the use of the same syringe to irrigate the ears. All these children were suffering from pertussis at the time.

**Pathology.**—The process is one of slowly spreading gangrene. In most of the cases there are thrown out inflammatory products in quite large amount, but there is little or no tendency to limitation of the disease. This usually advances steadily until death occurs. In a small number of cases a line of demarcation finally forms and the slough separates. Other infectious processes are likely to accompany the disease, particularly secondary pneumonia.

**Symptoms.**—The constitutional symptoms are not usually severe until the local disease has existed for several days. Then those of marked prostration and sepsis develop, sometimes quite rapidly. The temperature is usually elevated to 102° or 103° F., and sometimes to 104° or 105° F. There is dullness, apathy, feeble pulse, muscular relaxation, and very often diarrhea. Before death the temperature may be subnormal.

Of the local symptoms, often the first to attract attention is the odor of the breath; sometimes it is a dusky spot on the cheek or lip. On examination of the mouth, there usually is found upon the gum or inside of the cheek a dark, greenish-black necrotic mass, surrounded by tissues which are swollen and edematous, so that the cheek or lips may be two or three times their normal thickness. Externally the parts are tense and brawny from the swelling, this infiltration always extending



for some distance beyond the gangrenous part. As the process extends, the teeth loosen and fall out; there may be necrosis of the alveolar process of the jaw and perforation of one or both cheeks or lower lip; extensive sloughing of the face may take place, usually upon one side, sometimes upon both, giving the patient a horrible appearance. In one of our patients the process began in the right cheek, subsequently involving the left; perforation occurred in both cheeks, and before death a large part of the face was gangrenous. The odor from a severe case is very offensive, and, in spite of all efforts at disinfection, it may fill the ward or even the house. Pain is rarely severe, and in many cases it is absent. Extensive hemorrhages are rare.

We have notes of 7 cases in which noma affected the ear, being preceded by chronic otitis media in every instance. The disease began in the deeper structures of the canal, the first symptom noticed usually being a nodular swelling just beneath the ear, crowding the lobe upward. Shortly afterward there appeared a dirty brown discharge with a foul odor. Later, the gangrenous circle surrounded the meatus, which gradually extended, until in some cases the whole side of the face and head were involved. A probe could readily be passed through the bone into the cranial cavity. All these cases ended fatally.

The prognosis is grave, fully three-fourths of the cases proving fatal. The usual duration of the disease is from five to ten days. If recovery takes place, there is first seen a line of demarcation; then the slough is thrown off, and granulation and cicatrization begin, but require a long time, usually leaving an unsightly deformity.

Noma can hardly be mistaken for any other form of disease occurring in the mouth, and early recognition is of great importance, since only early treatment is likely to be successful.

**Treatment.**—Much can be done to prevent noma by prompt and thorough treatment of the benign forms of Vincent's infection. Particular attention should be paid to the mouth in the acute infectious diseases. Irrigation with an oxidizing agent should be carried out routinely whenever any form of stomatitis is present.

When gangrene has developed, radical measures should be adopted without delay. Complete excision of the gangrenous area should be done under anesthesia, care being taken to excise somewhat beyond the area of visible involvement. Following this, the margin of apparently healthy tissue should be cauterized either with concentrated nitric acid or with the Paquelin cautery.

Every case of noma should be isolated.

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## CHAPTER XXXVII

### DISEASES OF THE TEETH

Although the teeth do not strictly belong to the province of the physician, the responsibility of recognizing dental disorders and of instituting treatment often rests with him. Appreciation of the influence of diet upon the teeth and of the remote effects of oral sepsis have given the teeth an important place in the field of internal medicine.

**Malformations.**—*Supernumerary teeth* are not very uncommon. They are usually found among the incisors of the deciduous set. With the exception of the third molars of the permanent set, one or more of which are frequently missing, *deficiency of teeth* is quite rare. Lack of development of most or all of the teeth is, however, occasionally seen in conjunction with other ectodermal defects, particularly of the skin, hair and nails. Absence of the sweat glands is usually found in such patients and may produce very trying symptoms. In the child shown in the photograph on the following page, all the lateral incisors were missing.

Complete *deficiency of the enamel* is sometimes found, and may be a familial condition. Focal defects in the enamel are not uncommon.

**Dental Caries.**—Dental caries is an exceedingly common condition in children. It is found almost as frequently in the deciduous teeth as with the permanent set. Routine examinations of public-school children, made in various cities, have shown that fully 80 per cent have extensive caries. In groups where special attention is given to this subject the incidence is very much lower.

Among the causes of caries may be mentioned faulty diet, rickets and other conditions which affect the general nutrition, lack of dental care, and in certain instances congenital deficiency of enamel. The part played by neglect of the toothbrush has been much disputed, but there can be little doubt that the accumulation of food and secretions with acid fermentation favors erosion of the enamel and dentine. Much is done by the tongue and lips in removing such deposits; irregularities of dentition may interfere with this natural cleansing mechanism. The physical character of the food is important; tough fibrous foods exert a marked scouring action in contrast with the soft foods. The toothbrush and dental floss are valuable in supplementing these natural cleansing mechanisms and should by no means be neglected.

The rôle of diet in producing caries is not confined to its mechanical effect; the chemical composition appears to be of even greater import. The close association between caries and the excessive indulgence in sweets is a matter of common experience. The deleterious effect of cereals upon the teeth has been emphasized by M. Mellanby. Stefansson's observations upon skulls in the Arctic regions showed that caries was practically nonexistent before the introduction of cereal foods. It is quite possible, however, that this apparent deleterious effect of carbohydrates



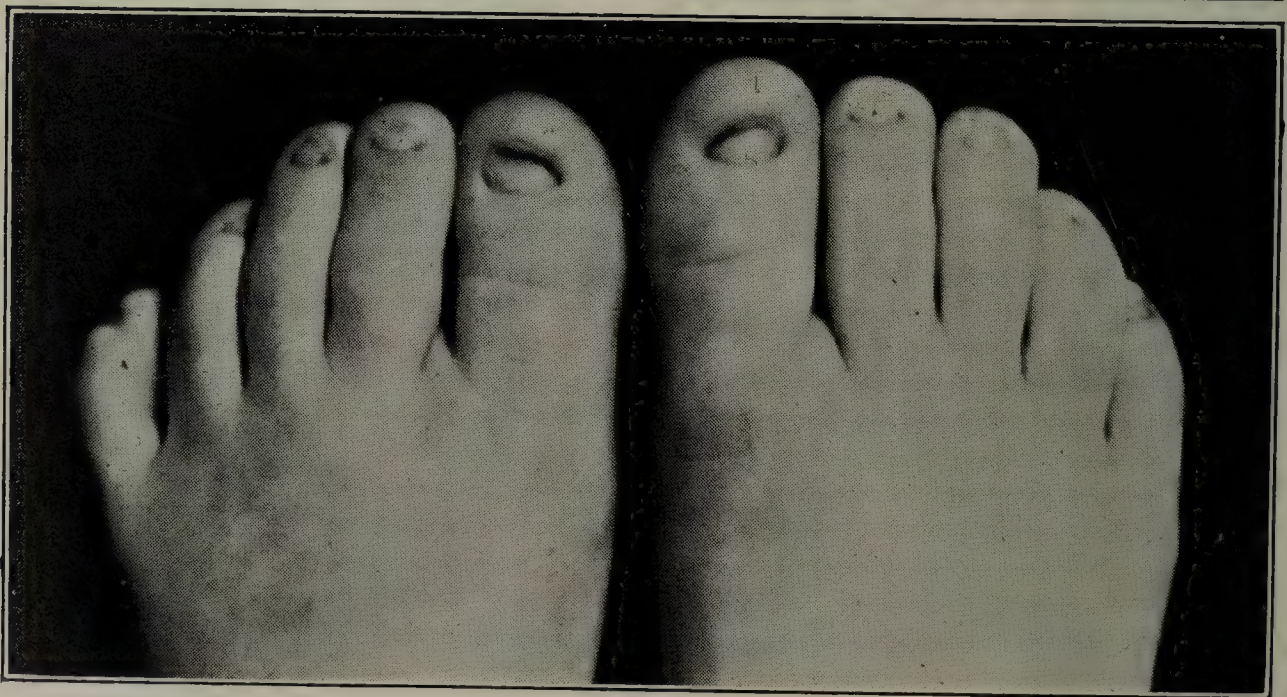
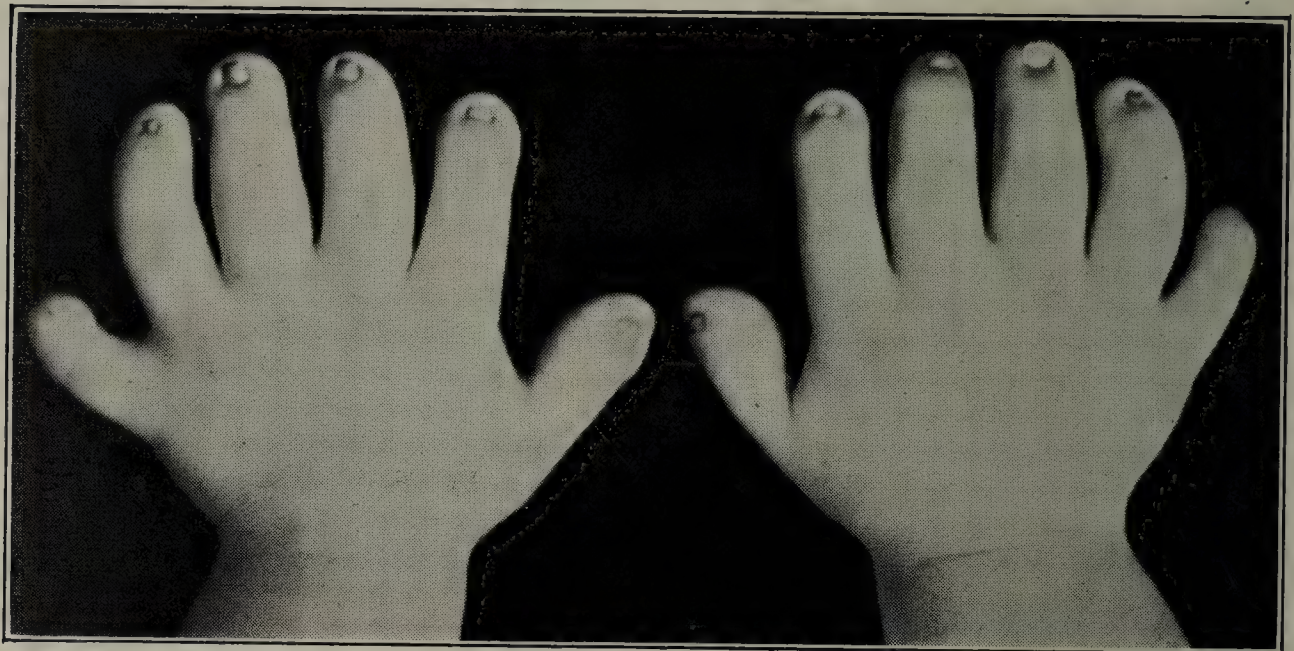


FIG. 47.—HEREDITARY ECTODERMAL DYSPLASIA, ASSOCIATED WITH POLYDACTYLISM AND CHONDRODYSTROPHY.

Bernice P. (B.H. 325872) weighed seven pounds, two ounces at birth. At this time nothing abnormal was noted except for the fact that she had six fingers on each hand, and both the hands and feet were somewhat short. Her neuromuscular development was exceptionally rapid; she sat up alone at five months and walked at nine months. Her growth in length, however, was retarded. The first tooth erupted at fourteen months of age. At four and a quarter years of age, she weighed 13.6 kilograms (29 pounds, 14 ounces), and measured 84 centimeters (33 inches) in length. She showed the typical long trunk and short extremities of chondrodystrophy. In addition the teeth were found rudimentary in form, all the lateral incisors being absent. Roentgen ray showed absence of developing tooth buds of all the incisors. Calcification of the deciduous teeth was complete. The finger nails and toe nails were of rudimentary form. The skin and hair were normal. No similar deformity was known in either branch of the parentage.



results not so much from their presence in excess as from the fact that other food-stuffs, particularly vitamin-rich fats and minerals, are then taken in diminished quantity. Boyd and his coworkers have shown that a balanced diet with an abundance of minerals and of all the vitamins will regularly arrest the progress of caries.

It might be expected that rickets and other chronic disturbances of the mineral metabolism should be predisposing causes of caries. Caries is indeed common under these conditions, but it is seen in the permanent set of teeth rather than the first teeth, since the former are being calcified at the time rickets and other nutritional disturbances are likely to occur. The changes in the teeth accompanying hereditary syphilis are discussed under that disease.

Two varieties of caries are seen. In the majority of instances the process is disseminated. It affects isolated teeth, the molars and premolars more often than the incisors. Decay usually begins in some depression of the tooth or at the gingival margin where particles of food are particularly likely to lodge; unless checked the erosion tends to advance until the entire tooth has been destroyed. In other instances there is a gradual decalcification which affects uniformly many or all of the teeth. It is often confined to the incisors, sometimes to the distal half of each tooth, which becomes much thinner than the portion nearer the root. Such teeth are fragile and are easily eroded. This type of disturbance may result from a congenital deficiency of the enamel or from some nutritional disorder; uncleanliness plays a much smaller part than in the first group.

The symptoms of caries are the result of infection of the dental pulp and the gums. Toothache may occur some time before the erosion has reached the pulp cavity.

Caries can largely be prevented by proper attention to diet and dental hygiene. Cod liver oil or some substitute should be given throughout infancy until a general diet can be taken. The use of the toothbrush and of dental floss should be encouraged. Alkaline mouth washes appear to have some value.

Routine examination of the mouth and prompt treatment of cavities will do much to prevent oral sepsis and its consequences. The deciduous teeth should be given as much attention as the permanent set; no greater mistake can be made than to assume that because a tooth is going to fall out it may be neglected. Small cavities should be filled; when this is impracticable, the question of extraction should be considered. This is a matter upon which opinion is divided. Early removal of deciduous teeth—the molars in particular—may permit the adjacent teeth to encroach upon the area from which the tooth was removed, causing deformity of the dental arch and irregular permanent dentition. On the other hand, a carious root may lead to oral sepsis with damage of the underlying permanent tooth, or to any of the remote consequences of focal infection. We are inclined to believe that each case should be judged upon its merits. One need have little hesitation in removing carious incisors or canines; there is little to be feared from the removal of carious molars if the time of eruption of the underlying permanent teeth is close at hand. In other instances conservative treatment would seem preferable. An important consideration is the urgency for removal of all possible foci of infection; in the presence of nephritis or chronic arthritis more radical treatment would seem justified.



Caries of the permanent teeth must be dealt with along the same lines as in adults. The sixth-year molars are particularly important in the development of the jaw and should be preserved if possible.

**Oral Sepsis.**—This is the end result of neglect of dental caries. It is common in the class of hospital and dispensary patients, among whom little attention is given to the teeth. The growth of bacteria in dental cavities may give rise to offensive breath and poor appetite. With the spread of the carious area infection may involve the gums, leading to *pyorrhea alveolaris*, or it may spread through the pulp cavity to the root of the tooth, where an *alveolar abscess* forms.

*Pyorrhea Alveolaris.*—This is usually seen only in association with advanced caries and in the region of the carious process. Occasionally, however, a generalized pyorrhea is found when the evidences of caries are minimal. It is probable that in such instances some unknown factor is present which predisposes to infection. Mellanby has offered evidence that deficiency of vitamin A plays a part. The infected gums recede from the teeth, forming pockets filled with pus between the tooth and the gum; these may extend clear to the tip of the root.

*Alveolar Abscess.*—Alveolar abscess may be acute or chronic. The acute cases are accompanied by severe pain and swelling, which may be limited to the gum ("gum-boil"), or may involve to a considerable extent the periosteum of the jaw and even cause swelling of the whole side of the face. Osteomyelitis of the jaw may result. Severe constitutional symptoms are usually present. It is important that such abscesses be opened promptly. Chronic alveolar abscesses usually fail to give local symptoms, but can readily be recognized by the x-ray. It is important not to interpret the shadow cast by a developing tooth as that of an alveolar abscess. The root of a permanent tooth develops in a sac of embryonic tissue which casts a shadow not unlike that of an alveolar abscess. Such a mistake in diagnosis may lead to the extraction of a normal tooth.

The general symptoms of oral sepsis result in part from poor appetite and improper mastication of food, and in part from the absorption of toxic bacterial products. The nutrition is likely to fail; anemia is often present. There may be headaches or muscular pains. In more marked cases there may be fever and swelling of the joints.

There can be no doubt that focal infections play an important part in many internal disorders of obscure origin—particularly of the joints and in certain types of renal disease. The prevention and the prompt treatment of oral sepsis is hence a matter of paramount importance.

**Difficult Dentition.**—The place of dentition as an etiological factor in the diseases of infancy is one which has given rise to much discussion. From a very early period the view has descended, that a large number of the diseases occurring between the ages of six months and two years are due to difficult dentition. The list of such diseases is a long one, but year by year it has been shortened as one after another has been shown to depend upon other causes, dentition being only a coincidence.

At the present time many good observers deny that dentition is ever a cause of symptoms in children, some even going so far as to say that the growth of the teeth causes no more symptoms than the growth of the hair. Although, no doubt,



the importance of dentition as an etiological factor in disease has been in the past greatly exaggerated, the careful and candid observer must admit that, particularly in delicate, highly nervous children, dentition may produce certain reflex symptoms.

It is our experience that fully half of the healthy children cut their teeth without any visible symptoms, local or general; in the remainder some disturbance is usually seen, and though in most cases it is slight and of short duration, it may last for several days or even a week. The symptoms most commonly seen are disturbed sleep, wakefulness at night and fretfulness by day. There is loss of appetite, and often, but not always, an increase in the salivary secretion, a slight amount of catarrhal stomatitis, and a constant disposition on the part of the child to put the fingers into the mouth. The weight often remains stationary for a week or two. The duration of these symptoms in most cases is but a few days, and they require no special treatment.

Symptoms more severe than the above are rare in healthy children. In delicate children there may be seen the symptoms already mentioned as occurring in healthy infants, but in greater severity; and in addition there may be attacks of acute indigestion. Occasionally there is an elevation of temperature to  $102^{\circ}$  or  $103^{\circ}$  F., lasting usually only two or three days, and accompanied by no symptoms except almost complete anorexia. It is occasionally, but rarely, seen that a child will have convulsions just before or during the eruption of each tooth. Such children are almost always the subjects of latent tetany, dentition acting as any other exciting cause to determine the onset of the convulsions. In cases of eczema the symptoms often undergo a distinct exacerbation with the eruption of each group of teeth. As regards almost all the other disease conditions which are commonly attributed to dentition, we believe that it is a delusion to ascribe them to this cause.

The physician should watch a child carefully, and examine him frequently, before he allows himself to make the diagnosis of difficult dentition. Probably in 95 per cent of the cases in which symptoms are present, they are due to some other cause. When, however, symptoms such as any of those mentioned disappear immediately when the teeth come through, and when we see them repeated four or five times in the same child with the eruption of each group of teeth, and accompanied by red and swollen gums, we cannot escape the conclusion that dentition is a factor in their production, though perhaps not the only one.

In the treatment of this condition special care should be exercised with respect to feeding. The strength of the food should be reduced, as well as the amount given. All the various devices for making dentition easy are useless. Lancing of the gums should be avoided. Unless the tooth can be pressed through the gum by gentle rubbing with the finger covered with sterile gauze, it should be left alone.

**Irregular Dentition.**—Aside from the congenital malformations already referred to, giving rise to an excessive or a deficient number of teeth, various post-natal disturbances cause irregular dentition. Any disease which retards the growth of the jaws is likely to cause crowding together of the teeth and thus produce unsightly deformities. Chronic mouth-breathing of any origin, but particularly when associated with enlargement of the adenoids, interferes with proper development of the alveolar arches. In persistent thumb-suckers the anterior portion of the mandible may be bent downward and the lower incisors displaced backward



while the upper incisors are pushed forward. As a result, when the molars are in occlusion the incisors may fail to meet by a gap of several millimeters. A similar separation of upper and lower incisors not infrequently follows severe rickets. In some cases the deformity corrects itself without special treatment during subsequent growth in the second decade, but at times it persists to adult life. It is not uncommon to find that, even when the alignment of the deciduous teeth has been perfect, as they are replaced by the permanent set the jaw appears to be too small for the latter; the incisors suffer most conspicuously. Too strict confinement of the young child's diet to soft and liquid foods, particularly in the first six years of life, may explain some cases. While no interference with health or general development results, the defect is unsightly.

Premature loss of deciduous teeth, from disease or surgical removal, may retard the growth of the jaw. The considerations to be borne in mind in the extraction of deciduous teeth have already been discussed (page 363).

It is not uncommon for one of the permanent teeth to erupt alongside the corresponding deciduous tooth without replacing it. The superfluous deciduous tooth should be extracted to allow the permanent one to grow into its proper position.

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## CHAPTER XXXVIII

### DISEASES OF THE ESOPHAGUS

**Malformations.**—Congenital anomalies of the esophagus are often associated with those of the lower part of the respiratory tract.

There may be: (1) Congenital fistula of the neck, due to a want of closure between the second and third branchial arches. This gives an external opening just above and to the outside of the sternoclavicular articulation, which communicates with the upper part of the esophagus or the lower part of the pharynx. (2) The esophagus may be absent, the pharynx ending in a blind pouch. (3) The esophagus may be obliterated in certain portions, being represented only by a fibrous cord. (4) There may be stenosis and dilatation or diverticula. (5) There may be fistulous communication with the trachea, existing either alone or associated with some of the other deformities mentioned. This is the usual variety met with; above, the esophagus terminates in a blind pouch; below, it communicates with the trachea a short distance below the larynx. The two parts of the esophagus may be connected by a fibrous cord.

Congenital narrowing of the esophagus and fistula of the neck are amenable to surgical treatment. The cases of complete obstruction in the esophagus are almost of necessity fatal, the patients dying from inanition four or five days after birth.

The symptoms of esophageal obstruction are immediate regurgitation on attempts at swallowing, and the impossibility of passing a stomach tube. An x-ray picture after the administration of barium often gives valuable information. Unless gastrostomy is performed the patients live but a few days; even after operation death follows from bronchopneumonia on account of the communication between trachea and esophagus which is usually present.

**Cardiospasm.**—This is occasionally observed in children as young as five or six years; it may occur even in infants. The onset may be insidious or the condition may follow in the wake of some acute disease. Difficulty in swallowing is the most striking symptom; it is seen in all degrees. In the mildest cases the spasm is incomplete, and the patient can often wash down the food with fluids. At times spasm is seen only at the commencement of a meal; when complete, not even fluids will pass through. The food is regurgitated after a variable length of time. The vomitus contains mucus, but it is unmixed with gastric juice and lacks the characteristic odor imparted by that secretion. Vomiting is never forceful. There may be continuous drooling on the pillow at night, or nocturnal attacks of choking due to the aspiration of regurgitated material. Pain is a variable symptom and may be dull and burning or sharp. It is brought on by the ingestion of food and is usually localized near the lower end of the sternum. The condition may disappear spontaneously in the course of a few weeks or it may persist for a longer time.



Cardiospasm may result in marked inanition. Abscess of the lung or bronchiectasis may follow as a result of aspiration of regurgitated food material.

Medical treatment is somewhat unsatisfactory. Atropine in full doses may be employed, but is often without benefit. A soft or semifluid diet offers less chance of obstruction. Warm food is more easily passed into the stomach than cold. Dilatation of the esophagus should be employed if the condition tends to persist; it should be attempted only by one with experience.

The more important inflammations of the esophagus result from mechanical or chemical trauma.

**Acute Esophagitis.**—It is quite remarkable, considering the frequency of inflammations in the pharynx, that these so rarely extend to the esophagus. Thrush, when very extensive in the pharynx, may involve the esophagus; but there it gives rise to no new symptoms. Diphtheria of the pharynx may invade the esophagus, but this is rare and produces no symptoms by which it can be diagnosed during life.

*Corrosive Esophagitis.*—This is altogether the most frequent form, and the only one which is of clinical importance. The usual cause is the swallowing of caustic alkalis or strong acids. Owing to the common practice of cleaning drains with a strong solution of lye, this is often within reach of small children; it is frequently mistaken by them for milk and some of it swallowed. It is in the esophagus that the most extensive injury is done. The effects are superficial or deep, according to the amount of the irritant swallowed and its degree of concentration. There may be simply a destruction of the epithelial layer, which is followed by no serious consequences, or the mucous membrane may be destroyed and the submucous coat invaded; rarely, however, does the injury extend to the muscular layer. If the patient survives the dangers incident to the irritant poisoning and the acute inflammation which follows, healing by granulation and cicatrization takes place, the contraction of the cicatrix gradually narrowing the lumen of the esophagus until stricture is produced.

The early symptoms of corrosive esophagitis are mingled with those of inflammation of the mouth, pharynx, and stomach. There is a burning pain in the parts, great thirst, profound prostration, and spasm of the esophagus on attempts at swallowing. There follows a period of acute inflammation of several days' duration, with great dysphagia and pain, in which the principal danger is edema of the glottis. After this the patient may be comparatively well until the symptoms of stricture begin, usually in from one to three months after the injury.

The indications for treatment in the early stages are: to neutralize the caustic in order to prevent if possible its deep action, to give oils, demulcent drinks and ice for the local effect, and morphine for the pain.

Bókay has advised a method for the prevention of stricture which is often very successful. On the second or third day after swallowing the irritant, a large catheter (usually No. 20, F) is introduced through the esophagus into the stomach. The openings in the end of the tube or catheter should be closed and the cavity filled with small shot. When the tube, corresponding in size to the age of the child, is well oiled it is passed with little difficulty or pain. It should be passed every two or three days at first, later once a week. Treatment is continued for eight or ten weeks. We have had excellent results with this method. It should be employed in



every patient who shows buccal lesions due to the caustic, whether or not a history of actual swallowing can be obtained.

When a stricture has developed the treatment is purely surgical.

**Retro-esophageal Abscess.**—Acute retro-esophageal abscess occurs in infancy, though very rarely, the pathological process being the same as in acute retro-pharyngeal abscess; the difference is merely one of location. The causes also are much the same. It may follow retropharyngeal abscess or one of the acute infectious diseases. The pus forms between the esophagus and the spine and varies in amount from a teaspoonful or two to four ounces. The symptoms are the general ones which accompany suppuration, with others due to pressure. At first there is an irritating cough; later when the abscess becomes larger there is dyspnea, which may be extreme. Dysphagia, regurgitation, or vomiting may appear. The condition is seldom recognized during life and in most cases a positive diagnosis is impossible. The most favorable termination is spontaneous rupture into the esophagus. In other cases death results from asphyxia or sepsis.

Retro-esophageal adenitis, or enlargement of the lymph nodes in this situation without suppuration, is also rare. We once met with a case of this sort in which the gland formed a tumor nearly an inch in diameter at the upper part of the esophagus, causing pressure symptoms necessitating tracheotomy. The growth was at first thought to be malignant, but eventually disappeared completely.

Retro-esophageal abscess may result from the breaking down of tuberculous lymph nodes in the posterior mediastinum, and may give rise to symptoms like those which result from an abscess due to Pott's disease.

Perforation of the esophagus and formation of a fistula connecting the esophagus and the trachea may result from ulceration caused by a tracheal cannula or by a foreign body. This may be accompanied by abscess.

The most common variety of retro-esophageal abscess is that due to Pott's disease of the lower cervical or upper dorsal region. The symptoms are obscure, and an exact diagnosis is not often made during life. Death may occur quite suddenly when the previous symptoms have been so slight as to be easily overlooked. The following is a fair example:

A girl two years old was admitted to our wards with caries of the upper dorsal region of two months' duration. The patient was kept in bed and a plaster-of-Paris jacket applied. About a month later dyspnea was first observed; this was at times quite intense, and again almost absent. It was always on inspiration, expiration being easy. No explanation for this was found in the lungs. There was no difficulty in swallowing, and very little cough. After these symptoms had lasted for about a week, the child while eating was suddenly seized with violent dyspnea, and in a few moments became completely asphyxiated. Tracheotomy was done with temporary relief. About two hours later a second attack occurred, which was fatal. At autopsy there was found a tuberculous abscess containing about two ounces of curdy pus, overlying the bodies of the first three dorsal vertebrae and communicating with them. These vertebrae were carious.

The diagnosis of this condition is very difficult. It may be suspected in cases of Pott's disease of the lower cervical or upper dorsal regions, when there is spasmodic inspiratory dyspnea, especially if accompanied by irritative cough. It should, however, be remembered that precisely similar symptoms may depend upon



the irritation of tuberculous nodes and that the sudden asphyxia is exactly like that caused by the ulceration of such a node into the trachea or a large bronchus. The latter, however, may occur without the presence of Pott's disease. If the abscess is higher up, there may be a swelling on either side of the neck, just above the clavicle. In most of the cases there are no external signs of disease. Such abscesses are too low to be reached by digital examination of the pharynx. The attack of asphyxia may also be confounded with that due to the presence of a foreign body in the larynx.

The prognosis in cases of retro-esophageal abscess is exceedingly bad. The abscess may rupture into the esophagus and recovery follow. The abscess may burrow along the esophagus into the abdominal cavity and excite peritonitis; finally, it may open externally.

But little is to be said under the head of treatment. The symptoms are rarely definite enough to justify a radical surgical operation. Tracheotomy gives but temporary relief to the asphyxia.

**Foreign Bodies in the Esophagus.**—This is a common occurrence in children, since any object upon which a child may lay hands is likely to find its way into the mouth. Only larger objects and those with sharp edges and angles are likely to become impacted; others pass into the stomach and rarely give trouble. A foreign body may become impacted at any point in the esophagus, most commonly at the upper and lower end. If allowed to remain it may lead to ulceration or perforation. The ulceration may occur into the trachea, or into the posterior mediastinum producing retro-esophageal or mediastinal abscess. A tracheo-esophageal fistula leads to aspiration pneumonia and lung abscess.

If the foreign body lodges in the throat it may give rise to gagging. In the esophagus itself it may cause only vague sensations of discomfort or none at all. The amount of obstruction is variable; it is seldom complete enough to prevent the passage of liquid foods, but solid and semisolid foods may be regurgitated. The regurgitated material may be aspirated into the larynx, causing attacks of choking and coughing. When there is laceration of the esophagus, ulceration and a more or less diffuse inflammatory process are likely to follow. In such instances there is pain and soreness on swallowing.

Many opaque foreign bodies can be localized accurately by x-ray or fluoroscopy. A flat object, like a coin, will usually lie in the frontal plane if it is in the esophagus; in the sagittal plane if in the larynx. Sounding is valueless and may cause further impaction of the object. The removal of foreign bodies should be left to the specialist in esophagoscopy. Clumsy attempts to remove an object impacted in the entrance of the esophagus not infrequently result in its aspiration into the larynx. With the esophagoscope, most foreign bodies can be withdrawn. Sometimes it is more convenient to push them down into the stomach. As a general rule, any object that reaches the stomach in this way can ultimately be passed by rectum without further assistance. No special dietary measures are called for. Cathartics are contraindicated.



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## CHAPTER XXXIX

### DISEASES OF THE NOSE AND PHARYNX

**Malformations.**—Aside from harelip and cleft palate, congenital malformations of the nose are uncommon. Membranous or bony septa closing the choanae are occasionally seen. The obstruction is usually opposite the posterior end of the inferior turbinate bone. We have seen two such cases. The condition is not likely to be overlooked, because of the difficulty in nursing. The patient is unable to breathe with the mouth shut; the alae nasi do not dilate with inspiration. In one of our cases there was a chronic infection of the nose and sinuses, probably the result of instrumentation. After artificial openings in the membrane were made, progress was satisfactory and the infection cleared up. Prolonged dilatation was, however, required.

**Deviation of the Nasal Septum.**—This is almost always traumatic rather than congenital in origin. It is uncommon in young children. If possible, operative procedures should be postponed until the age of puberty, for the development of the nose is likely to be interfered with if much of the septum is removed. If the obstruction interferes with nasal breathing or if a chronic sinus infection is present it may be necessary to remove part of the septum at an earlier date.

### THE COMMON COLD

**Etiology.**—The common cold is an acute catarrhal inflammation involving the upper respiratory passages. Although it is, beyond a doubt, an infectious process, the etiological agent is still unknown, nor is it clear that a single agent is responsible.

Bacteriological studies of the nose and throat during colds have shown organisms indistinguishable from those normally present. Various strains of staphylococci, streptococci, pneumococci, influenza bacilli, *M. catarrhalis*, diphtheroid bacilli, etc., may be found. In the early stages few organisms are present; later on they are abundant. Although one or another of these organisms may be found in pure culture, particularly when the infection extends to the middle ear or the sinuses, it is now believed that they are not the primary cause of the disease. It has been well demonstrated by Dochez and others that colds may be transmitted to apes and to man by filtrates of nasopharyngeal secretions taken in the early stages of a cold. The ordinary bacteria appear to play a secondary rôle, and may be responsible for spread of the infection to adjacent structures. There is evidence suggesting that the primary cause of colds is not always the same; in different epidemics the clinical picture shows considerable variation in severity, in communicability and in symptoms. In some epidemics the disease tends to localize first in the larynx, in others in the nose and pharynx.



**Immunological Considerations.**—That the common cold is usually acquired by direct contagion is unquestioned. It was formerly believed that autogenous infections were not infrequent, and that chilling and other factors which lowered the resistance of the individual enabled the bacteria normally present in the throat to invade the tissues. Although this possibility cannot be denied, recent evidence indicates that exposure and chilling will not produce the disease unless the infectious agent is also present. It seems likely that the infectious agent may be carried for some days by resistant individuals without evidence of disease; under these conditions a temporary lowering of resistance may precipitate an attack.

The factors which govern resistance to colds are very incompletely understood. All individuals are in some degree susceptible, but some are throughout life far more susceptible than others. This lack of resistance may be familial; it may be associated with chronic disturbances of nutrition; infants with rickets are especially susceptible. Local causes play a very important part; allergic inflammations or foci of disease in the nose or throat increase the susceptibility to colds; the removal of diseased tonsils may be followed by a great reduction in the number of these infections. The lowered resistance caused by exposure and chilling of the body is probably due to a localized cooling of the nasopharynx, the temperature of which may fall several degrees. In susceptible children a trivial exposure, such as a draught of cold air for a few minutes, may be sufficient to precipitate an attack.

The incubation period of colds cannot be stated with accuracy, since the onset of symptoms may be more closely related to some predisposing factor. It seems likely that symptoms may develop within twenty-four hours, although at times it may be thirty-six or forty-eight hours.

The duration of the infective period appears to be five or six days after the onset of symptoms; colds are more contagious in the early stages.

The immunity developed in the course of an attack is largely local, a fact which is responsible for some of the clinical features of the disease. The development of immunity in the nose or pharynx confers no immunity upon the tissues of the larynx and *vice versa*; thus the disease may be found healing in one region and beginning in another. There is a considerable amount of epidemiological evidence which indicates that immunity lasts from four to seven weeks following an attack. The familiar phenomenon of "catching more cold" may not represent a true relapse, but may be due to secondary invaders.

Colds are more common during the cold months of the year. The reason for this is not altogether clear. Several factors may be responsible: climatic conditions affecting the temperature of the throat, confinement indoors with lack of sunshine and greater possibility of contagion, and perhaps in addition heightened virulence of the infectious agent due to more frequent passage from one susceptible individual to another.

It does not appear that young infants acquire colds more readily than older children or adults. However, the younger the child the more serious these infections are likely to prove. The infection is more likely to spread and complications are more frequent. Furthermore, the unfavorable influence exerted by these infec-



tions upon the nutrition of young infants makes their control a matter of the first importance.

**Pathology.**—The common cold produces only a superficial catarrhal inflammation; the process does not extend beneath the submucosa; it does not lead to ulceration.

**Symptoms.**—The rapidity of onset varies greatly in different epidemics; in some it is rapid, in others insidious, and several days may elapse before one is certain that infection is actually present. Local symptoms usually start in the nose, but may begin in the pharynx or the larynx; the process may remain localized or extend upward involving the conjunctivae, ears or sinuses, or downward to the trachea and bronchi. There is first noticed a sensation of itching or burning in the region affected. The onset of coryza is often marked by sneezing. In the earliest stages the mucous membrane is dry but within a few hours it becomes intensely congested; there is a copious discharge which is at first serous but subsequently becomes mucous and mucopurulent in character. Congestion of the erectile tissue covering the turbinate bones causes obstruction of the nasal passages and mouth-breathing. Smell and taste are largely abolished. As the discharge continues there may be excoriation of the nostrils. A mild conjunctivitis usually accompanies the coryza.

With involvement of the pharynx and tonsils there is likely to be a rough scratchy feeling at the back of the throat and a dry unproductive cough. Swallowing is unpleasant and there may be a disinclination to take food. Sleep is disturbed and there is usually snoring. There may be enlarged tender lymph nodes at the angle of the jaw or referred pains in the neck.

Laryngitis is accompanied by hoarseness or complete aphonia. There is a barking, metallic cough, and a sensation of discomfort localized over the larynx. Spasm is often present in young children and causes the characteristic stridor and dyspnea. With extension to the trachea and bronchi, cough is a prominent symptom and is often accompanied by pain in the chest. Diffuse râles are present.

The amount of constitutional disturbance varies greatly in different epidemics. Young infants are regularly fretful and irritable; there is usually some fever, which may be as high as 103° or 104° F. With older children it is seldom higher than 102° F. Leukocytosis is not often seen unless complications are present. The appetite is impaired, and if food is forced it may be vomited. In small infants the associated digestive disturbance may take the form of a diarrhea; in older children temporary constipation is more common.

**Course.**—The duration of colds is exceedingly variable. When the infection remains localized it seldom lasts longer than a week, but with extension of the process or relapses it may continue for several weeks.

**Complications and Sequelae.**—The most important complication of the common cold is otitis media. Routine examinations of the ear drums have shown that slight evidences of congestion are present in nearly every case. It is uncommon to find any further inflammatory changes except in infants and young children, in whom suppurative otitis media is all too common. On this account the ears should be examined regularly in all infections of the nose and pharynx.

The accessory nasal sinuses are frequently involved in the acute stages of colds.



but chronic sinus infections seldom follow. A common cold may be the starting point for pneumonia or a generalized septic infection, although such a termination is rare.

Although the large majority of colds are benign infections and may be lightly regarded, this does not hold for young infants. The more serious nature of such infections in these subjects is due in part to the greater frequency of complications, but more particularly to the unfavorable influence exerted upon the digestion. The tolerance for foodstuffs, particularly for carbohydrates and fats, is likely to be impaired. Unless the food is promptly reduced diarrhea or vomiting may occur. Such disturbances are not uncommon, but they are usually transient; with recovery from the infection the tolerance for foodstuffs is quickly regained. In a certain number of infants, however, particularly in those who are feeble or premature, the intolerance for food remains for a long time; a serious nutritional problem results which may terminate fatally. In such subjects the development of a cold is to be regarded with apprehension.

**Diagnosis.**—Symptoms indistinguishable from those of a common cold may occur at the onset of certain infectious diseases. An acute coryza may usher in an attack of measles. A sore throat may be the first manifestation of scarlet fever, streptococcus angina or diphtheria. An apparently simple coryza or tracheobronchitis may prove to be the early stage of pertussis. Congenital syphilis should always be thought of with a persistent rhinopharyngitis in young infants. From sporadic influenza no exact differentiation is possible. Infections characterized by marked constitutional disturbance are usually labeled influenza.

Hay fever, the allergic cold, may give rise to confusion in children older than four or five years; it is seldom seen before that age. The seasonal type is usually recognized without difficulty. It should be remembered, however, that a variety of animal and vegetable proteins may be inhaled at any time of year and may give rise to periodic attacks of coryza.

Irritating chemicals may produce symptoms indistinguishable from a cold. Attacks which follow sudden exposure to cold may be confused with the common cold; there may be sneezing, congestion of the mucous membranes and a sero-mucous discharge developing rapidly, often within a few minutes after chilling or after return to a warm environment. The duration of these attacks is brief, seldom more than an hour. They are to be regarded as vasomotor disturbances of thermal origin rather than as genuine infections.

**Prophylaxis.**—The prevention of colds consists in avoidance of infectious contacts and in maintaining or building up individual resistance. Complete isolation from possible contacts is not practicable except for small infants, but in view of the more serious consequences in them it should be rigidly enforced. Persons suffering from colds should not be allowed to come near an infant, particularly during the first five or six days of their infection. When contact is unavoidable, as with the mother or nurse, the infectious person should wear a gauze mask over the nose and mouth, and should be careful to wash her hands before handling the infant. The promiscuous kissing of infants on the mouth should not be permitted.

With older children, particularly in cities and in the winter months, it is difficult to prevent exposure to colds. One must usually rely on maintaining individual



resistance. Attempts to meet all changes in the temperature of the environment with suitable changes in clothing are not likely to be successful. The usual result is an overclothed child who perspires continually and thus often catches cold more frequently than would otherwise be the case. A better plan is gradually to accustom the child to temperature changes by the judicious use of hardening procedures. One of the best of these is a daily cold bath. Clothing should never be so warm as to lead to visible perspiration, either by night or by day.

Removal of foci of infection such as chronic sinuses, diseased tonsils and adenoids will often cause a great diminution in the number of colds. Malformations of the nasal septum or polyps may be responsible for chronic infections and indirectly predispose to colds.

Vaccines are often used but convincing proof of their efficacy has never been brought forward.

**Treatment.**—It is doubtful if any form of therapy will shorten the course of a cold. All that one can expect to accomplish is symptomatic relief and the prevention and early recognition of complications.

*General Measures.*—As far as is practicable the patient with a cold should be isolated, particularly when there are young children or infants in the family. Rest in bed is advisable as long as fever is present. Much can be done to avoid digestive upsets by a prompt reduction in diet. This is of particular importance in infants; their food should be cut in half, the amount being gradually increased during convalescence. Fluids should be freely given. Sedatives are indicated when cough is a severe or distressing symptom, or when sleep is interfered with. Codeine or the various barbitol preparations may be used. We have found luminal a convenient drug. Aspirin, phenacetin and other antipyretics may be given to older children. They seem to have some influence in diminishing headache and feelings of general malaise. It is not our practice to employ them with infants.

*Local Treatment.*—Local treatment of the nose and throat in infants may well be omitted. The instillation of mineral oil into the nostrils, once a common procedure, has been largely given up because of the danger of lipoid pneumonia produced by accidental inhalation. With older children sprays may be used. Some relief may be obtained from the inhalation of menthol preparations. The congestion of the mucous membranes is greatly diminished and the nasal obstruction temporarily relieved by the use of an epinephrine spray. A less transient effect is produced by ephedrine. Some individuals are unable to take these drugs because of their local irritative action. They may well be omitted with infants. It is not our practice to employ atropine. Given in sufficient dosages it will dry up the nasopharyngeal secretions, but the inflammation and the discomfort remain. Gargles may be used with older children when pharyngeal soreness is marked. They may give some symptomatic relief; their antiseptic action is, however, negligible.

The treatment of laryngeal spasm is considered elsewhere. With *laryngitis*, *tracheitis* or *bronchitis* accompanied by an unproductive cough, great relief may follow the use of expectorants. Those commonly employed are ipecac and potassium iodide. Steam inhalations are very effective. With infants and children too young to use an inhaler a croup kettle may be used. Some flavoring material such as compound tincture of benzoin is often added (one teaspoonful to one pint of



hot water), but it is the hot vapor rather than the drug which causes the expectorant effect. The use of sedatives for an unproductive cough has already been mentioned.

### CHRONIC NASAL DISCHARGE

This is a common condition in infancy and childhood. One should not make the mistake of regarding it as a simple chronic rhinitis and treating it by constitutional measures. It is a symptom which may be due to a variety of conditions, and demands a thorough study of the nasal passages. Syphilitic rhinitis is a common cause in young infants; nasal diphtheria may occur at any age. In both of these conditions the discharge is likely to be profuse and blood-streaked. A chronic discharge may be due to sinusitis, to nasal infection associated with adenoids, polyps or foreign bodies, or with deviation of the septum and other traumatic or congenital deformities.

*Foreign bodies in the nose* are quite frequent in young children; they should be suspected whenever there is an abundant mucopurulent discharge limited to one nostril. Peas, beans, beads, or shoe buttons are most frequently lodged there. The efforts at removal on the part of the child, or the parents, generally result in pushing the body farther into the nose. It first sets up a mechanical irritation, accompanied by pain, swelling, sneezing, and sometimes hemorrhage. This is followed by a catarrhal inflammation which in the course of a few days becomes purulent and may last indefinitely. The discharge is generally quite abundant. The symptoms point to an obstruction of one nostril, and an examination with a probe or speculum readily detects the presence of the foreign body.

The removal of the foreign body may sometimes be accomplished by compressing the empty nostril and having the child blow his nose strongly. Often the sneezing which the foreign body excites is sufficient to remove it. Before any attempt is made to seize the body with forceps, novocaine with epinephrine or ephedrine should be used to prevent pain and to contract the mucous membrane so as to allow better manipulation. General anesthesia is rarely necessary. No subsequent treatment is required, except the use of some mild antiseptic to keep the nose clean for a few days, as the inflammation quickly subsides after the removal of the cause.

*Nasal polyps* are the result of inflammatory conditions in which a portion of the mucosa has become pedunculated. They are usually associated with sinusitis. They may be accompanied by reflex symptoms, such as coughing, sneezing, and even by attacks of asthma. There may be headache, and sometimes disturbances of smell, taste, and hearing. The symptoms develop insidiously and are of much longer duration than in the case of obstruction from a foreign body; the discharge is not so abundant, and is not purulent. The diagnosis is made only by local examination.

A unilateral discharge may be due to *sinusitis*, but more often the discharge is bilateral.

### CHRONIC RHINITIS

**Simple Chronic Rhinitis (Hypertrophic Rhinitis).**—This is usually due to a focus of infection in the sinuses or in the adenoid tissue of the pharynx. Often there is a history of frequent attacks of acute coryza; in older children



allergic rhinitis (hay fever) may be a predisposing factor. The condition is characterized by hypertrophy of the nasal mucous membrane, particularly the erectile tissue covering the turbinate bones. Congestion of the latter may cause nasal obstruction which shifts from side to side with change in posture. The mucous membranes of the nose are found deeply congested. There may be a profuse discharge anteriorly (with excoriation of the nostrils in children too young to blow the nose) or a postnasal discharge. Epistaxis is not uncommon. The condition is always aggravated by each succeeding acute infection.

Treatment consists in avoiding attacks of acute coryza and in removing the causes of the chronic infection—clearing up sinus infections, removing adenoids. Nasal irrigations may be of benefit, but there is always some risk of infecting the middle ear. Saline or some mild antiseptic solution like Dobell's may be employed. Aspiration of the nasal secretion is a more effective and less dangerous way of clearing out the nasal cavities. Applications or sprays of epinephrine or ephedrine are useful in shrinking down the congested mucous membranes and give marked symptomatic relief. In some individuals they are irritating when used in effective concentrations. Excision and cauterization of the turbinate bones are to be avoided in children.

**Atrophic Rhinitis.**—This is rarely met with in children. Its etiology is obscure; it is found in run-down individuals and in some instances follows hypertrophic rhinitis. There is atrophy of the nasal epithelium and of the mucous glands in the nose. The character of the epithelium changes, becoming cuboidal and then squamous; in places it may desquamate altogether. There is very little secretion; crusts tend to form over the ulcerated areas. The sense of smell is usually lost. On examination the nasal cavities appear unusually wide; the inferior turbinate bone may disappear in part and there are crusts visible over scattered areas. The process may spread to the pharynx.

A very characteristic complication of atrophic rhinitis is *ozena*, which is due to a secondary infection with a putrefactive organism, giving the nasal breath an extremely foul odor. Not all cases of atrophic rhinitis are complicated by *ozena*, and this condition is sometimes met with in sinus disease, in syphilis and other conditions without atrophic rhinitis.

Treatment is a slow and difficult process at best. Repeated irrigations, loosening the crusts, oxidizing agents like hydrogen peroxide have been of value. Dean recommends a solution of iodine in glycerin.

## EPISTAXIS

**Etiology.**—Epistaxis is a rare symptom in the newly born, and when present suggests syphilis. It is infrequent throughout infancy, but in childhood it is quite common, occurring in boys more frequently than in girls. In the latter it is especially common about the time of puberty, being eventually outgrown. The exciting cause of epistaxis may be a local one, like a fall or blow; it may be due to picking the nose, or to any kind of mechanical irritation; in such cases the hemorrhage does not always follow immediately. It is often caused by a small ulcer on the septum or by a local inflammatory process; simple rhinitis seldom causes bleeding, but congenital syphilis and nasal diphtheria are common causes.



Any condition which raises the blood pressure may bring on an attack of epistaxis—mental or physical excitement, or a severe paroxysm of pertussis. It occurs occasionally as an early symptom in many febrile diseases—in measles, typhoid, malaria or rheumatic fever; it is seen in the hemorrhagic form of all the eruptive fevers, in septic infections and in diseases of the blood and blood vessels—anemia, leukemia, purpura and scurvy.

A rare cause of epistaxis is multiple hereditary telangiectasia of the nose; we have seen a family in which all the children were so affected.

**Symptoms.**—The hemorrhage is usually unilateral; it may come from any part of the nasal fossa, but usually from the anterior nares, most frequently from the vessels of the septum. The amount lost is generally small, but it may be large enough, when repeated, to produce a serious grade of anemia even in strong children; the hemorrhage may even prove fatal. Epistaxis may be overlooked if the blood finds its way into the pharynx and is swallowed. In most of the cases the hemorrhage ceases spontaneously in from ten to twenty minutes, recurring at longer or shorter intervals according to the nature of the cause. Hemorrhage from adenoid growths of the pharynx may closely resemble that from the nose, but otherwise there can rarely be any difficulty in recognizing epistaxis.

**Prognosis.**—This depends upon the cause. In the great majority of the so-called idiopathic cases epistaxis is not serious. Occurring early in the course of one of the infectious diseases, it does not ordinarily affect the prognosis unless it is very severe. When it occurs late, however, it is always a bad sign, and particularly so in diphtheria. It may be serious in any of the hemorrhagic diseases or in diseases of the blood, in which it is not infrequently a cause of death.

**Treatment.**—An efficient means of arresting the hemorrhage is compression of the nose between the thumb and finger. This may be combined with the application of ice over the nose, and sometimes small pieces of ice may be introduced into the nostrils. The application of cold to the back of the neck or its use in the mouth may be of service by exciting reflex contraction of the capillary vessels. The child should be kept quiet—with sedatives if necessary. After the hemorrhage has ceased he should not blow his nose for some time. Epinephrine or ephedrine are most efficient local measures for checking the bleeding. Another valuable remedy is peroxide of hydrogen, used full strength. The commercial anticoagulant preparations have in our experience proved useless. If bleeding continues in spite of all the above measures, the anterior nares should be packed, and if this does not control it, the posterior nares should be packed. Usually very little effect is seen from drugs given internally.

Continued bleeding not due to local causes will sometimes yield readily to injections of horse serum or human serum; the latter is to be preferred. From 20 to 30 c.c. may be given to a child of five years and repeated every few hours if bleeding continues. In very severe hemorrhages transfusion may be necessary. In severe cases of nasal hemorrhage recurring at short intervals without any apparent cause, ulcer of the septum should be suspected, and, if present, should be touched with chromic acid.



### ADENOIDS

This term is given to a mass of lymphoid tissue normally situated at the vault of the pharynx, which in structure closely resembles the tonsils. It is often spoken of as the pharyngeal tonsil. Like the faucial tonsils, this may become diseased or hypertrophied. It may form a tumor large enough to fill the rhinopharynx completely. These tumors have a broad attachment which is sometimes more to the roof, and sometimes more to the posterior wall of the pharynx. In infancy these growths are soft, vascular, and spongy; in older children they become firm, dense, and more fibrous. Adenoid vegetations are associated with hypertrophy of the faucial tonsils in a large proportion of the cases. Growths large enough to cause decided nasal obstruction may in time produce changes in the facial bones amounting to positive deformity. The bony palate may be dome-shaped or even acutely arched; the dental arch of the upper jaw becomes almost V-shaped. Deformities of the thorax also occur, which will be described with the symptoms.

**Etiology.**—Hereditary influences certainly play some part in the production of this condition. Frequently every one of a large family of children may be affected, and often the parents have suffered from the same condition. Adenoids are most common in damp, changeable climates. Their first symptoms often follow an attack of measles, scarlet fever or diphtheria. The repeated attacks of rhinopharyngitis associated with adenoid growths are more often a result than a cause of the condition. Adenoid growths are said to be much more common in well-nourished than in poorly nourished children. Not rarely they are the seat of tuberculosis. Of 945 cases collected by Lewin in which specimens of adenoids were examined, tuberculosis was present in 5 per cent. Though this proportion is possibly higher than is found in private practice, the association is an important one.

**Symptoms.**—The symptoms of adenoid growths are usually first noticed when children are from eighteen months to three years old; but they may be present to a marked degree almost from birth. They generally increase as age advances until the age of six or seven is reached, being always better in summer and worse in winter. The symptoms relate to (1) chronic rhinopharyngeal catarrh, (2) mechanical obstruction, (3) otitis and other aural conditions, (4) general malnutrition and anemia, (5) reflex nervous phenomena.

The rhinopharyngeal catarrh shows itself by persistent nasal discharge, or frequently recurring head colds during the winter season. In susceptible children these attacks are often followed by bronchitis, which may keep a child indoors almost the entire winter.

The obstructive symptoms are inability to blow the nose, mouth-breathing constantly or only during sleep, and a nasal voice. The difficulty in breathing is increased when the child lies upon the back. In consequence of this, children sleep in all sorts of positions—lying upon the face, sometimes upon the hands and knees—and often toss restlessly about the crib in the vain endeavor to find some position in which respiration is easy. The attacks of dyspnea at night may amount almost to asphyxia, and are the explanation of many of the so-called night-terrors



from which children suffer. When the obstruction has existed from infancy there are often deformities of the chest; these are most marked in rachitic subjects. The most frequent one consists in deep lateral depressions of the lower part of the chest, with a prominence of the sternum. The deformity is due to interference with pulmonary expansion. There is sometimes seen a flattening at the root of the nose, and a prominence of the transverse vein in this region.

Some impairment of hearing exists in a large proportion of the cases. Deafness may be due to tubal catarrh or to otitis; it is often due merely to mechanical obstruction of the eustachian orifice.

Attacks of spasmodic croup are often associated with adenoid growths, the removal of which is followed by the complete cessation of such symptoms. At other times there is intractable cough without bronchial symptoms or signs, and often hoarseness lasting for months, and recurring during each cold season for years. Recurring attacks of asthma seem at times to be dependent upon these growths.

The reflex symptoms ascribed to adenoid growths have been greatly exaggerated. Children become nervous if they have obstructive symptoms with disturbed sleep, or if they spend much of the time in bed or in the house. Such children present a number of nervous manifestations that may be due to other factors quite as much as to adenoid growths. Headaches are common. Stammering, chorea and even epileptiform seizures have been attributed to adenoid growths, but without sufficient justification. Incontinence of urine is very rarely cured by the removal of such growths.

The general health of patients suffering from adenoid growths may be impaired from loss of sleep and from confinement to the house necessitated by attacks of bronchitis or rhinopharyngitis, or from absorption when these growths become infected. There may also be enlargement of the cervical lymph nodes. Anemia is often present. In long standing cases of a severe character, children have a dull and stupid facial expression. They are languid, listless, inattentive, often depressed and this, associated with deafness, frequently causes them to be backward in school; when operation is performed their subsequent improvement shows that they are not mentally deficient.

The natural course of the growths if left to themselves is to increase up to a certain point, then to remain stationary until puberty, when they usually undergo some degree of atrophy. This, with the marked increase in the capacity of the rhinopharynx which occurs at this time, results in a disappearance of the most aggravated symptoms. The removal of the patient to a warm region with a dry atmosphere will often result in diminution in the size of the growth and relief from all symptoms, but unless such a change in residence is permanent the symptoms are likely to return. Under ordinary conditions there is little or no tendency to spontaneous recovery. In children with marked adenoid growths attacks of diphtheria, scarlet fever, measles, and whooping cough are all likely to be more severe.

**Diagnosis.**—In a well-marked case the condition is usually evident from the history, and can scarcely be overlooked. The intractable nasal catarrh, mouth-breathing, disturbed sleep, and the slight deafness—all are characteristic. Other



patients come for treatment on account of malnutrition, nervous symptoms, headaches, or anemia. In rare cases the leading symptom may be epistaxis.

Only an examination can make it certain that an adenoid growth exists. It is ordinarily felt as an irregular, granular, soft, velvety mass, or sometimes as a tumor completely blocking the passage; the finger, when withdrawn, is frequently covered with blood. By pharyngoscopy, the growth in older children can be seen.

**Treatment.**—The spontaneous disappearance of adenoid growths is possible only when they are small. This is aided by removal to a warm, dry climate for the winter season. With the larger growths this may improve the catarrhal symptoms, but can hardly affect the obstructive ones. The reduction of tumors of any considerable size by local applications is a delusion.

Removal of adenoid growths is indicated: (1) when the obstructive symptoms—habitual mouth-breathing, disturbed sleep, nasal voice, chest deformities, etc.—are marked; (2) for a chronic nasal discharge, constantly recurring attacks of rhinopharyngitis, particularly when these tend to develop into bronchitis or laryngitis; (3) when there is asthma or repeated attacks of catarrhal spasm of the larynx; (4) with deafness, chronic otitis, or repeated attacks of acute otitis. Although striking improvement is not infrequent, one should be cautious about promising too much from operation, especially as regards the nervous conditions; also in older children when there is deafness or asthma.

The preferable time for operation is the late spring or early summer, in order that during the warm months the mucous membranes may have an opportunity to regain their normal condition; however, operation may be done at any time except during attacks of acute rhinopharyngitis. Unless the symptoms are very marked, it is desirable to defer operation until a child is at least two years old. Recurrences are occasionally seen even after a thorough operation by an experienced surgeon; but most of them are due to the fact that the primary operation was incomplete. The risks and complications of operation are considered in connection with tonsillectomy. The improvement generally begins in a few days, sometimes at once, though the full benefit may not be seen for two or three months. The breathing becomes freer, the sleep more quiet; voice and hearing improve, and the benefit to the general health is soon apparent. The pallor, listlessness, and inattention disappear, and a rapid increase in weight often follows. The entire appearance of the child may, in a few months, be transformed.

In some instances the lymphoid tissue extends to the eustachian orifices and pedunculated growths may cover them completely. Surgical removal of growths in this particular region is best avoided. After the usual adenoid operation portions of the growth adjoining the eustachian orifices are best treated with radium.

## SINUSITIS

Disease of the nasal accessory sinuses is more common than was formerly supposed. Many cases of sinusitis in adults originate as childhood infections.

**Development of the Sinuses.**—Infection of the sinuses is dependent on their anatomical development; until they have reached an appreciable size they are of no clinical importance. Pneumatization of the sinuses begins by proliferation of the epithelium at the ostium of the sinus; the bone is eroded as the air sac



lined with epithelium advances. The process begins before birth in some of the sinuses. The maxillary sinus (antrum) and the ethmoidal cells are well developed at birth, and continue to grow rapidly thereafter; either of these may be the seat of infection, even in young infants. Infection of the antrum has been reported in an infant only three days old. The sphenoidal sinus, although present at birth, is very small. It does not begin to grow rapidly until after the third year, and is seldom large enough to be of clinical importance before the sixth year. The frontal sinus is not present at birth; it is formed by an outgrowth of ethmoid cells into the frontal bone. Pneumatization is not appreciable before the second or third year; disease of this sinus is rare before the tenth year.

**Etiology.**—As is the case with upper respiratory infections in general, sinusitis is a disease of cold, damp and changeable climates; along the north Atlantic seaboard it occurs almost exclusively in the winter and spring months. It originates from infection in the rhinopharynx, usually a common cold, sometimes a contagious disease like measles or scarlet fever. In other instances the infection may spread upward from chronic infections of the tonsils and adenoids. The removal of tonsils and adenoids is, however, of questionable value in preventing sinus infections; Kaiser found sinusitis slightly more frequent in children who had had their tonsils and adenoids removed. Sinusitis is a common complication of cleft palate and is often responsible for the failure of plastic operations. Deviation of the nasal septum—a common cause of nasal obstruction and sinusitis in adults—is of little importance in childhood.

**Pathology.**—In acute sinusitis the mucous membrane is the seat of acute inflammation, and the lumen of the sinus is filled with mucopurulent or purulent secretions. This may clear up entirely or may give way to a chronic process; the membrane then shows subacute inflammatory changes, round cells replacing the polymorphonuclear leukocytes. There may be great thickening of the membrane due to connective tissue infiltration. The epithelium loses its columnar character, becoming cuboidal or even squamous; in places it may be destroyed, being replaced by scar tissue.

Extension of the inflammation to the adjacent bone is more frequent in children than in adults, perhaps because the bones of the child are softer. There may be swelling of the soft parts or abscesses of the cheek or orbit. Less commonly the process extends to the eye, the cavernous sinus or the meninges. In the eye it may affect the cornea, the uveal tract, the retina or the optic nerve or all of these structures.

The most important remote effects of sinus disease are chronic arthritis, chronic bronchitis and asthma. Sometimes very dramatic results are obtained by clearing up a chronic sinus infection.

**Symptoms.**—These may not be in any sense characteristic. There may be a profuse nasal discharge appearing anteriorly or a postnasal discharge discovered on inspection of the throat. Sinusitis is, however, only one of the causes of such a discharge. The discharge may be unilateral or bilateral. If the outlet of the sinus is blocked, the sinus empyema is likely to give more pronounced constitutional symptoms, but no discharge appears in the nose. There is usually an associated rhinitis, sometimes with nasal obstruction. Tenderness and edema over the af-



affected sinus are not always present, but when present are very helpful signs. With ethmoidal involvement edema appears first on the inner side of the eye and base of the nose; the upper lid may be affected later. In older children localized pain and headache may be of assistance; there is often a sensation of fullness in the head. The pain is usually localized directly over the affected sinus. Disease of the sphenoid sinus causes pain in the teeth or in the suboccipital region.

The diagnosis must usually be made by special examinations. An antero-posterior x-ray is of great value in showing whether the suspected sinuses are sufficiently developed to be of clinical importance; there are great individual variations in the formation of the sinuses. Involvement of the frontal sinus can be detected by clouding in the x-ray or by local tenderness and pain. With the other sinuses, x-rays and transillumination are of little help in children; the diagnosis must be established by procedures requiring the services of a rhinolaryngologist. Nasopharyngoscopic examination may reveal pus coming from the ostium of the sinus; when wiped away it reappears at once. The maxillary sinus (antrum) may be aspirated and the washings examined for pus and cultured. A similar procedure may be used with the sphenoid sinus, but cultures are in this instance of less value because a sterile technic cannot be observed. However, recovery of a hemolytic streptococcus not present in the nasopharynx may be significant. Anesthesia is usually required for such procedures.

Acute cases of sinusitis usually recover without any treatment; operative interference is seldom required.<sup>1</sup> Recovery in most instances is complete; in only a small proportion of the cases does the process become chronic. Acute sinusitis usually declares itself, but a chronic process may require a most careful search with aspiration and culture before it is discovered.

**Treatment.**—The question of local treatment of acute and chronic sinusitis is often a matter of nice judgment. In acute conditions investigation of the sinuses is justified if, in the presence of a nasopharyngeal infection, there are unexplained septic symptoms. Local suppuration in the cheek and orbit demand surgical intervention. Edema of the face does not necessarily indicate an abscess, and does not in itself call for sinus drainage; in many instances this will subside spontaneously.

How radical one should be in discovering and treating chronic sinus disease will depend on the severity of complications. With progressive chronic arthritis more radical methods are justified than in uncomplicated infections. Removal of tonsils and adenoids clears up a great many sinus infections—82 per cent according to Dean. One should not operate for this in the presence of an acute upper respiratory infection, but should if possible wait until the patient is afebrile; in some instances fever does not subside entirely and it may be necessary to neglect

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<sup>1</sup> The following is an instance of a severe sinus infection in a young child. G.C. (H.L.H. 52244), a seven-months-old colored infant, developed a cold which was followed by high fever. When seen six days after the onset the temperature was 104° F., there was a profuse bilateral purulent nasal discharge, edema around the left side of the nose and the left eyelid, especially the lower lid; there was slight left exophthalmos. The spleen was palpable. Exophthalmos increased and on the eighth day an orbital abscess was incised (Dr. Wilmer) after cutting the superior oblique muscle. There was profuse drainage and the temperature gradually fell to 100° or 101° F. Three weeks later the temperature again rose to 104° F. A radical antrotomy was done (Dr. Crowe) and the left maxillary sinus and ethmoid cells were found full of pus; the temperature again declined gradually. Recovery was complicated by the development of otitis and mastoiditis which also required operative treatment, but was eventually complete, the patient being discharged well two and one-half months after the onset of his illness.



this precaution. A change of climate often clears up a chronic sinus. A warm, dry climate such as that of Arizona or New Mexico is most beneficial; many months may be required. Drainage of the sinuses may be resorted to if tonsillectomy and adenoidectomy are ineffective and a change of climate is not possible; intranasal drainage suffices, external operations being required only when fistulas develop. Local irrigations with antiseptic solutions may be of some help. The same may be said of vaccines. With the most resistant antrum infections, stripping of the affected mucous membrane has been practiced with success, but should be undertaken only as a last resort. This procedure cannot be carried out with the other sinuses.

## ACUTE PHARYNGITIS

Acute pharyngitis may exist as a primary disease, or with any of the infectious diseases, particularly scarlet fever, measles, diphtheria, or influenza. Certain children have a constitutional predisposition to attacks of acute pharyngitis, and contract it upon the slightest provocation. Attacks often follow exposure. In many cases they are associated with disturbances of digestion. These causes probably act by producing local and general conditions favorable to the development of micro-organisms already present in the mouth. The bacteria most frequently associated with severe attacks are streptococci, staphylococci, pneumococci, and less frequently the influenza bacillus.

In acute pharyngitis the inflammation may involve the entire mucous membrane of the tonsils, fauces, uvula, posterior and lateral pharyngeal walls, or any part of it. It may exist alone, or in connection with a similar inflammation in the rhinopharynx or in the larynx. In the beginning there is seen an acute redness, usually involving the entire pharynx. This may entirely subside after twenty-four hours, or it may be followed by the usual changes of acute catarrhal inflammation—dryness, swelling, and edema. Later there is increased secretion of mucus, and finally mucopus. In infants as a rule the accompanying changes in the tonsils are relatively mild and inconspicuous. After the first or second year the same disease process appears to express itself mainly in tonsillar signs and symptoms, and this clinical picture is described below under acute tonsillitis; actually, the whole pharynx usually shares in the inflammation. Under the same epidemiological and environmental conditions, children whose tonsils have been removed may continue to have occasional attacks of acute pharyngitis, with all the systemic symptoms of acute tonsillitis. In some of these patients there is often seen at the height of the disease an associated involvement of the follicular lymphoid tissue on the posterior pharyngeal wall and on the faucial pillars, each follicle being swollen and shiny and at times containing a central core of white material representing a minute follicular abscess.

In acute pharyngitis there is pain at the angle of the jaws, increased by swallowing, also a sensation of dryness and roughness in the pharynx, and often an irritating cough. There may be swelling of the neighboring lymph glands. The constitutional symptoms in young children are often severe. Not infrequently there is a sudden onset with vomiting, and a rise of temperature to 102° or even 104° F. These symptoms are usually of short duration, frequently less than



twenty-four hours, and in two or three days the patient may be entirely well. Acute pharyngitis may be accompanied by or followed by laryngitis, but especially in infants, more often by acute otitis.

Acute primary pharyngitis is to be distinguished from scarlet fever, diphtheria, measles and influenza. A positive diagnosis from scarlet fever is impossible until a sufficient time has elapsed for the eruption to appear, and the patient should be closely watched for the first sign of this. If scarlet fever is prevalent, a child with the symptoms of severe pharyngitis should at once be isolated while waiting for the diagnosis to be determined. There is commonly less difficulty in excluding measles because of the absence of Koplik's sign, and of the accompanying catarrh of the eyes and nose. Catarrhal diphtheria can be excluded only by culture.

The child should be kept in bed, and the diet should be fluid, or, in the case of infants, the amount of food reduced. Ice may be swallowed frequently for the relief of pain and thirst. Aspirin or phenacetin may be given for the systemic symptoms. The disease is not serious, and the indications are to make the child comfortable during the short attack and to watch for signs of acute otitis, which is the most important complication.

### DISEASES OF THE TONSILS

**Acute Tonsillitis.**—The tonsils are affected in many acute diseases—in diphtheria, syphilis, measles, scarlet fever, Vincent's infection, colds, etc.; the characteristics of these infections are considered elsewhere. Acute tonsillitis due to pyogenic organisms may occur in connection with other diseases, or may be an independent primary infection. Sometimes the pneumococcus or staphylococcus is responsible, but the great majority of instances are due to streptococci, either of the nonhemolytic, the viridans or the beta-hemolytic groups. Most of the severe cases are due to beta-hemolytic organisms.

Acute tonsillitis is not common in early infancy, but after the first year it is very frequent. In many instances the infection seems to be autogenous, originating from a focus of infection within the tonsil; under the influence of some factor which lowers resistance, the infection flares up and spreads. This is probably the case in children who have repeated attacks of tonsillitis and whose tonsils remain hypertrophied between attacks. In other instances the infection is acquired from without; in its most virulent form (septic sore throat) it may assume the character of an epidemic.

**Pathology.**—The inflammation of the tonsil is usually bilateral and is associated with more or less pharyngitis. There is marked swelling and congestion of the tonsil, with proliferation of lymphoid tissue. As a result of the inflammation, the tonsillar crypts may be filled with fibrin, epithelial debris, pus cells, mucus and bacteria; these form masses which appear at the mouth of the crypts as yellow dots and can be squeezed out (*follicular tonsillitis*). Minute abscesses may form in the lymph follicles, not only of the tonsils but in the pharyngeal wall as well.

In the more severe cases, patches of pseudomembrane may form on the tonsils and surrounding structures (*membranous tonsillitis*). The structure of the membrane cannot be distinguished from that found in diphtheria. There is intense congestion, edema and cellular infiltration of all the lymphoid and cellular tissue



of the pharynx; the inflammation may extend to the uvula, soft palate, epiglottis, the adenoid tissue of the entire pharyngeal vault, and sometimes to the external lymph nodes and cellular tissue of the neck as well. The process may terminate in resolution, suppuration or necrosis; septic complications are commonly met with.

*Symptoms.*—Constitutional symptoms are often quite prominent and commonly precede the local manifestations. The onset is usually abrupt, the temperature rising to 102° or 103° F.; in the severe cases it may be 104° or 105° F. In infants there is likely to be vomiting and diarrhea, perhaps a convulsion; in older subjects there may be chilly sensations or definite rigors, headache, pains in the back and extremities.

The first local symptoms are sore throat and pain in the neck; there may be difficulty or discomfort in swallowing. On inspection of the throat the tonsils are found swollen and inflamed; they may meet in the midline. There may be the typical picture of follicular exudate, the crypts being marked by yellow spots the size of a pinhead, or there may be a membranous patch, yellow or dirty gray in color. Membrane is sometimes loosely attached and can be easily wiped off, in other instances it can be removed only with difficulty. Swelling and tenderness of the lymph glands behind the angle of the jaw may be marked in severe cases.

The constitutional symptoms, as a rule, last only three or four days and are most severe on the first day. The local symptoms last somewhat longer, but usually by the end of the fourth day the exudate has disappeared, although enlargement of the tonsils may persist for a week or even longer.

*Diagnosis.*—Acute tonsillitis cannot be distinguished with certainty from diphtheria on clinical grounds. It is, therefore, safest to regard every case as suspicious and to make routine throat cultures. Antitoxin can be withheld pending the bacteriological examination, unless the case strongly suggests diphtheria and is a severe one. If there is a membranous patch one should not withhold antitoxin. Active immunization does not by any means exclude the possibility of diphtheria.

Scarlet fever may at the outset be confounded with simple tonsillitis. One should always bear this possibility in mind and search for a rash.

*Treatment.*—Isolation is desirable in every case of tonsillitis. Ordinarily, it is a mild disease without danger to life, running a self-limited course. Only symptomatic treatment is required. Antipyretics such as salicylates, pyramidon or phenacetin may be employed to reduce the fever and muscle pains. Two grains of phenacetin may be given every four hours to a child of three years; enough should be given to make the patient comfortable.

Local treatment may well be omitted with infants; at the most it should be confined to instillation of 10 per cent argyrol in glycerin through the nose. Gargles and sprays of some mild antiseptic like Dobell's solution may be used with older children. Painting the tonsils with 2 per cent silver nitrate or 20 per cent mercurochrome may at times be beneficial.

After an acute attack it is advisable to examine the urine for two or three weeks; the development of a late nephritis sometimes gives the clue to a case of scarlet fever which had hitherto been regarded as simple tonsillitis. Scarlet fever without a rash sometimes occurs. Because of the association of tonsillitis with



rheumatic infections, the heart should be kept under observation, particularly in children who suffer from repeated attacks of tonsillitis.

**Epidemic Tonsillitis (Septic Sore Throat).**—This deserves separate consideration. The infection is usually due to a very virulent strain of beta-hemolytic streptococcus; it is often spread by milk; the source may be a dairy employee or disease of the udder of the cow. The local and constitutional symptoms are unusually severe. The angina is membranous or phlegmonous and the inflammation spreads to surrounding structures in the throat and neck. There is high fever and great prostration. In many cases there is a streptococcus septicemia with pyemic manifestations; the mortality runs between 15 and 20 per cent.

Such cases should be rigidly quarantined. They require more intensive local treatment than the ordinary case of acute tonsillitis: the swelling of the throat may be allayed by frequent spraying with epinephrine or ephedrine; cold applications should be applied for cellulitis of the neck.

**Agranulocytic Angina.**—This term has been applied to a group of cases characterized by ulcerative lesions in the mouth, particularly on the tonsils, marked fever and constitutional symptoms, and an aplastic anemia with leukopenia and great diminution of the polymorphonuclear leukocytes. The condition is often fatal, but recovery may occur.

Whether this symptom complex is a manifestation of Vincent's infection or of something else is not clear at the present time. Certainly the Vincent spirillum can be found in many of these cases. We have seen the clinical picture of agranulocytic angina develop in the course of an aleukemic leukemia. It may be that the growth of this organism or its clinical manifestations are favored by absence of granular leukocytes; on the other hand, the infection itself may be responsible for the blood picture.

**Phlegmonous Tonsillitis (Peritonsillar Abscess; Quinsy).**—This is an inflammation of the cellular tissue surrounding the tonsil, sometimes invading the tonsil itself. It may terminate in resolution, but usually goes on to the formation of an abscess. Phlegmonous tonsillitis is much less common in children than in adults, and, compared with the other forms, it is rare in early life. It is the only variety which is regularly unilateral. In most cases the process is circumscribed, but in rare instances there is seen a diffuse phlegmonous inflammation of the pharynx.

In certain patients there exists a predisposition to the disease. The exciting cause may be exposure, or anything which may reduce the patient's general health, to which there is added local infection. When there are repeated attacks on the same side a purulent focus in the tonsil is reasonably certain.

**Symptoms.**—The onset resembles that of follicular tonsillitis; the temperature is often high, and the muscle pains and prostration are severe. There is acute pain in the throat, which is increased by deglutition, and finally may be so great that swallowing is almost impossible. It is difficult to open the mouth. There is pain in the lateral muscles of the neck and often tenderness. In the beginning but little can be seen on inspection, even though the patient complains of a very sore throat. This is always a suspicious circumstance, and should lead one to look out for quinsy. It is due to the fact that the inflammation begins in the deeper tissues, and that the mucous membrane is affected later.



After twenty-four or forty-eight hours there is usually quite marked swelling, which is rather more behind the tonsil than elsewhere, pushing it upward and forward; sometimes it is more in front of the tonsil. A little later there is intense inflammation of the mucous membrane covering the tonsil, fauces, and uvula with edema and sometimes a fibrinous exudate; the uvula may be pushed to one side, and the isthmus of the fauces diminished to barely one-half its natural size. Marked torticollis may be present.

In most cases the recognition of quinsy is quite easy by attention to the symptoms above mentioned. By inspection of the throat less information is sometimes obtained than by palpation; by this means a fullness, and later a point of fluctuation, can readily be made out.

Acute phlegmonous tonsillitis generally involves no danger to life. In very young infants serious results may follow spontaneous rupture during sleep; and in older children occasionally there may be edema of the glottis. If not treated, an abscess usually forms in from five to seven days, and opens spontaneously.

*Treatment.*—Many drugs have been advocated, salicylates in some form being generally employed. Relief may be afforded by very hot or cold applications, according to the sensations of the patient. The holding of ice in the mouth and the application of an ice-bag, externally, often give great comfort. In other cases, gargling with very hot water and hot applications externally will be preferred.

As soon as fluctuation is detected an incision should be made with a guarded knife into the fluctuating area. A general anesthetic is contraindicated. If made too early, only a small amount of pus is evacuated and the abscess may refill. After spontaneous rupture or evacuation the relief of symptoms is usually immediate. An attack of quinsy is a definite indication for tonsillectomy.

**Hypertrophy of the Tonsils (Chronic Tonsillitis).**—Hypertrophy of the tonsils is met with in acute tonsillitis; the condition is often temporary and subsides following the attack. The condition known as chronic hypertrophy is a permanent enlargement, due to a proliferation of the lymphoid tissue of the tonsils and an increase in the connective tissue stroma. If the increase in the connective tissue is slight, the tonsil is soft; if it is great, the tonsil is firm and hard, almost like a fibrous tumor. All degrees are found. Such tonsils may or may not harbor foci of infection. Associated with hypertrophy of the tonsils there are usually found adenoid growths of the pharynx, both of these depending upon similar causes. A chronic pharyngitis is often present.

*Etiology.*—Hypertrophy of the tonsils is an exceedingly common condition in the cities of the seacoast and lake districts of the temperate zone. In a routine examination of 2000 New York school children, Chappell found enlargement of the tonsils sufficiently marked in 270 cases to be considered pathological. In dry, warm climates hypertrophy of the tonsils and adenoids is distinctly unusual.

This condition must be regarded as a response to local infection. The lymphoid tissue of the pharynx unquestionably affords a barrier to the invasion of pathogenic organisms; in the presence of infections it proliferates. Although it is common enough to obtain a history of repeated upper respiratory infections in cases with marked hypertrophy, this is not always true. It would seem that in some instances infections are so well handled that the resulting hypertrophy of the ton-



sils and adenoids is the only clinical manifestation. Individuals respond very differently in this respect; in some families there is a tendency to extreme enlargement of the tonsils. The lymphoid tissue of the body is influenced to some extent by the nutrition of the individual; in states of malnutrition it tends to diminish and atrophy. Czerny observed that well-nourished children had larger tonsils, but his conclusion that hypertrophy is the result of overfeeding seems hardly justified.

While it is true that hypertrophy of the tonsils is a defense mechanism, and that the enlarged tonsil may be an asset to the body, this is not necessarily the case. Much of the structure of the tonsil may be destroyed by disease, and it may harbor foci of infection with pyogenic organisms or tuberculosis which are a real menace to the body.

*Symptoms.*—Hypertrophy of the tonsils is rarely marked enough to cause any decided symptoms before the end of the second year, although occasionally in younger children enlargement sufficient to bring the two tonsils into contact may be seen. Obstructive local symptoms—mouth-breathing, disturbed sleep accompanied by snoring, and nasal voice, otitis media, sinusitis, and chest deformities—are due to the associated hypertrophy of the adenoids.

It is the presence of disease, rather than the size of the tonsil, which gives symptoms. A chronically infected tonsil may give rise to repeated acute attacks of tonsillitis; there may be a low-grade irregular fever, with pains in the muscles and joints and other indefinite symptoms of illness which may persist for months. There may be evidences of renal irritation—albumin and casts in the urine.

Tonsils which are enlarged may not be easy to recognize. The hypertrophy may be obvious enough and the tonsils almost meet in the midline, but in other cases the tonsils are buried and inspection of the throat gives little idea of their size; a much more accurate impression can be obtained by palpation.

*Treatment.*—The question of removing tonsils is often a difficult one to decide. It is generally conceded that only diseased tonsils should be removed, but the difficulty comes in deciding when disease is present. A diseased tonsil may be presumed if there is extreme hypertrophy, if the tonsil is firm or spongy and if there are systemic signs of focal infection, or enlarged and tender cervical lymph nodes. A test often employed—probing the tonsil to see if pus can be extruded—is of little value. Probing may cause the extrusion of a small amount of yellow fluid from a crypt, but this usually consists of epithelial debris, mucus and saprophytic bacteria rather than pus.

The removal of moderately enlarged tonsils is sometimes urged even in the absence of any of the above criteria on the grounds of prophylaxis against rheumatic infections and nephritis. The statistics of Kaiser would seem to give support to this contention. In a series which included more than 4000 tonsillectomized children with an equal number of controls in which operation was advised but not done, he found that the subsequent incidence of rheumatic fever and acute nephritis was distinctly lessened in those operated upon. On the other hand, the children who retained their tonsils suffered less frequently from sinusitis and pneumonia. Operations upon the tonsils are seldom indicated before the third year, but one should not hesitate to recommend tonsillectomy in young children or even in infants if the indications are definite.



Of the various operative procedures, complete enucleation is always to be preferred. Local anesthesia is not practicable in young children; a general anesthetic is always required. In the hands of a skilled operator the only dangers are those of late hemorrhage and postoperative pneumonia. Hemorrhage of a severe grade is rare in children; in most cases it occurs within the first twenty-four hours, but it may occur some days later. It may be controlled by packing and application of epinephrine, or by ligation of bleeding points. Fatal hemorrhage, except in patients with some abnormality of the blood-coagulation mechanism, is almost unknown. Postoperative lung abscesses may result from aspiration of infectious material during the operation; much can be done to prevent this by attention to the child's position and by the proper use of suction. The postoperative pneumonias can usually be attributed to the irritating action of the anesthetic.

Radiation of enlarged tonsils with radium or x-ray was introduced some years ago and has been widely employed. In some instances the results were satisfactory, but in others destruction of the tonsil was accomplished only with much scarring, or else incompletely, and foci of infection were not eliminated. Subsequent operation upon such tonsils was very difficult. Although radiation may have a place, particularly in patients who are bleeders, it is not to be recommended for general use.

### RETROPHARYNGEAL ABSCESS

Two distinct varieties are seen: (1) the so-called primary abscesses of infancy, and (2) abscesses secondary to caries of the cervical vertebrae.

**Acute Retropharyngeal Abscess.**—The process is an inflammation of the lymph nodes with secondary cellulitis and suppuration. The retropharyngeal nodes form a chain on either side of the midline between the pharyngeal and prevertebral muscles. Retropharyngeal abscess—or, more properly, retropharyngeal adenitis, for suppuration does not always take place—is probably never primary; it usually follows attacks of acute pharyngitis; it is an uncommon sequel of measles and scarlet fever. The inflammation is due to pyogenic organisms—usually streptococci or staphylococci. As a rule only a single node is involved, but sometimes two or three may be affected; these may be situated upon opposite sides. Often there is an associated adenitis of the cervical lymph nodes or the nodes at the base of the tongue.

These cases are quite common and the great majority occur in infants. The disease is more frequently seen in the winter and spring; it occurs as often in children previously robust as in those who are delicate; it is unusual after the second year. It has been stated that atrophy of the retropharyngeal nodes after the third year explained the absence of the disease in later childhood. It is more probable that the incidence in early life is due to the fact that the young infant possesses little acquired resistance to infections; in the absence of acquired immunity infections penetrate more readily to the regional lymph nodes. (See page 59.)

**Symptoms.**—There may be the history of a preceding attack of acute pharyngitis. After this has subsided the temperature may remain slightly elevated, often for a week or more, before the local symptoms are noticed. Sometimes, without any distinct history of previous catarrh, there is seen a high temperature, from 102° to 104° F., with loss of weight and prostration. A careful examination may



be required, and sometimes observations for a day or two, before the explanation of these constitutional symptoms is discovered. In other cases the early constitutional symptoms are so slight as to escape notice, and the local symptoms are the only ones present. Although usually these are not severe, retropharyngeal abscess may cause dyspnea, which in a short time assumes an alarming character. The duration of the inflammatory process before the abscess forms is generally five or six days, but it may be several weeks. The temperature is invariably elevated, usually from 100° to 103° F.; occasionally it may be 104° or 105° F., with symptoms of prostration seemingly out of all proportion to the local disease, but which are to be explained by the extreme youth and feeble resistance of the patient.

The most characteristic local symptoms are the posture (the head being drawn far backward to relieve pressure on the larynx), the noisy respiration with the mouth open, usually some difficulty in deglutition and external swelling. Sometimes the first thing to attract notice is a sudden attack of severe dyspnea. This may be due to the pressure forward of the abscess encroaching upon the air passages. Retraction of the neck and dyspnea are more marked when the abscess is situated low down in the pharyngeal wall. The mouth may be dry, or there may be a copious secretion of pharyngeal mucus. The dyspnea is greater on inspiration, and in some it is noticed only then. The difficulty in swallowing is greater when the tumor is low down. The child may find it impossible to swallow, and in consequence may refuse to nurse; or the difficulty in nursing may depend upon the nasal obstruction. Sometimes there is regurgitation of food through the nose or mouth. Dehydration of marked degree is sometimes observed in cases that have gone for several days unrecognized. The voice has a peculiar muffled nasal quality which is quite characteristic. Generally there is no aphonia. Usually there is some swelling externally, below the angle of the jaw in front of the sternomastoid muscle; exceptionally this may be more prominent than the internal swelling. Occasionally torticollis is an early symptom.

On inspection of the throat there is usually seen a distinct bulging of the lateral wall of the pharynx. The swelling may crowd the uvula to one side and nearly fill the pharynx. It is rarely in the median line. There is usually redness of the mucous membrane and edema of the uvula and of the adjacent parts. On digital examination the swelling is made out even better than by inspection. It may be situated so low down as not to be visible at all. In the early stage there may be felt only a localized induration or a somewhat diffuse swelling, but by the time the swelling is large enough to produce marked symptoms, fluctuation can generally be discovered. Care should be taken in making digital examinations. We have seen in delicate children alarming symptoms follow even when manipulation was brief.

Cases of retropharyngeal adenitis which do not go on to suppuration may give local and constitutional symptoms quite as severe as those described.

*Prognosis.*—When left to itself the abscess usually opens into the pharynx, the pus being swallowed or expectorated, but unfortunately it may also be aspirated. The cavity may close rapidly by granulation, and in a few days the patient be entirely well; or the abscess may refill. Spontaneous external rupture almost never takes place. It is rare for much burrowing to occur. In young or very deli-



cate infants the constitutional symptoms may be so severe that the child continues to fail even after the evacuation of the abscess, and dies, usually from bronchopneumonia.

Death may occur from asphyxia due to pressure upon the larynx, to edema of the glottis, from rupture of the abscess into the air passages, especially if this occurs during sleep, or from secondary pneumonia. Carmichael, Bókay, and others have reported deaths from ulceration into the carotid artery or one of its large branches. Carmichael's patient was only five weeks old. The general mortality is about 10 per cent; many deaths result from a failure to make the diagnosis. We have known unexpected death to occur in two cases shortly after the opening of the abscess, apparently from shock, which in these patients is sometimes very great. In one case death was due to a secondary retro-esophageal abscess.

*Diagnosis.*—Retropharyngeal abscess is to be suspected if in an infant there is difficulty in swallowing, noisy dyspnea, mouth-breathing, and retraction of the head. A positive diagnosis is possible only by a digital examination of the pharynx. The mistake most often made is that the great dyspnea has led to a diagnosis of laryngeal stenosis, and tracheotomy or intubation has been performed before making a careful examination of the pharynx. Many such cases are reported in which the child has died during the operation or immediately afterward, the autopsy first revealing the nature of the disease. A sudden attack of dyspnea like that caused by the rupture of an abscess may be produced by the lodgment of a foreign body in the pharynx or larynx. We once saw in an infant a sarcoma of the lymph nodes which gave an external and internal swelling like that of a retropharyngeal abscess.

*Treatment.*—Before the abscess has pointed, hot applications may be made to the throat to relieve the symptoms and to hasten the formation of pus. Spontaneous opening should never be waited for, on account of the danger of the rapid development of serious symptoms from pressure or edema, or of suffocation from rupture into the air passages.

When the diagnosis is made the patient should be carefully watched, and as soon as a point of fluctuation is detected, but not before, the pus should be evacuated. In opening through the mouth, which is always to be preferred, the patient should lie on the back with the head low. An anesthetic is not required. The use of a mouth-gag may cause asphyxia. The abscess may be opened with a knife which has been guarded to its point by winding with adhesive tape, or better with a pair of blunt pointed scissors or with an artery clamp. Aspiration with a blunt needle of large caliber is entirely satisfactory. After opening it is well to insert a clamp into the cavity to enlarge the opening and break down any septa; for after a simple puncture the abscess may refill. The amount of pus evacuated varies from one dram to half an ounce. In the majority of cases no after-treatment is required. The relief of the dyspnea and dysphagia is usually immediate, and recovery rapid. But young or delicate infants should be very closely watched for some time on account of the dangers mentioned.

**Retropharyngeal Abscess from Pott's Disease.**—This form is rare in comparison with that just described, and under three years of age it is extremely so. These abscesses are usually larger, and the amount of pus contained may be from



four to eight ounces. They form very much more slowly, often lasting for months, and as with other tuberculous abscesses, the constitutional symptoms are seldom severe. The swelling is frequently in the median line, and is not so circumscribed as in the nontuberculous cases. The pus often burrows along the spine for several inches. The symptoms of Pott's disease of the cervical region are usually present for several months before the appearance of the abscess. Sometimes the abscess precedes the deformity, and it may be the first intimation of the existence of bone disease. External swelling is usually seen, and it may be quite large, extending almost from one ear to the other, forming a distinct collar. On digital exploration there may be found an irregularity of the anterior surface of the cervical vertebrae, and occasionally a marked angular prominence.

When left to themselves these abscesses may open externally in front of the sternomastoid muscle just below the jaw, sometimes nearly as low as the clavicle; they may rupture internally into the pharynx, the esophagus, or the air passages; or they may burrow a long distance in front of the spine. Death may result from pressure upon the larynx, or from rupture into the larynx, trachea, or pleura; all these, however, are rare. The abscesses not infrequently refill after they are evacuated, and occasionally a discharging sinus is left for many months.

*Treatment.*—Pressure symptoms are not as common as in the acute pyogenic variety, and local treatment of the abscess can often be indefinitely deferred. If relief of pressure is imperative, it may be obtained by aspiration or, if necessary, by incision and drainage through the side of the neck. Owing to the danger of secondary infection of the abscess cavity with mouth organisms, the peroral approach should not be used. In most cases the general treatment of the tuberculous patient (see page 1032) and the orthopedic treatment of the carious spine give the maximum benefit to the local condition as well. Provided the abscess does not become secondarily infected, the prognosis depends mainly on the severity of the tuberculous process in the spine and on its distribution elsewhere in the body.

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# CHAPTER XL

## DISEASES OF THE EAR

### ACUTE OTITIS MEDIA

This is one of the most frequent infections met with during infancy and childhood. Like most respiratory diseases it is more common in the cold season; in a study made in the Harriet Lane Home by D. T. Smith, otitis media was found in 47 per cent of hospital patients during the month of February and in 24 per cent of patients in the month of July. Most of these cases were under three years of age. The frequency of otitis at different ages is well illustrated by the following table taken from Smith:

TABLE XXXI  
FREQUENCY OF OTITIS MEDIA AT DIFFERENT AGES

Age	0-3 Mos.	3-6 Mos.	6-9 Mos.	9-12 Mos.	1-2 Yrs.	2-3 Yrs.	3-5 Yrs.	5-10 Yrs.	10-14 Yrs.	All Ages
Number of patients.....	73	54	47	46	103	73	44	107	40	587
Per cent showing otitis media .....	22	57	62	52	48	40	27	7	0	34

As a rule, acute otitis is a secondary disease. It is a common complication of infectious diseases, particularly scarlet fever, measles, pneumonia, pertussis and diphtheria. It is often associated with disease in remote parts of the body, such as pyelitis, dysentery and other gastro-intestinal disorders. In such instances the infection is apparently blood-borne, but in the majority of cases it is an ascending infection from the pharynx by way of the eustachian tube. Any inflammation of the pharynx may be followed by otitis; the common cold is a frequent cause. A chronic focus of infection, such as diseased adenoids, tonsils or paranasal sinusitis, may be responsible for repeated acute attacks or for the persistence of the disease in chronic form.

A number of factors contribute to the peculiar susceptibility of infants and young children to otitis. The eustachian tube in the infant is wider and shorter than in later life; the persistence of embryonic mesenchyma in the tympanic cavity provides a tissue easily infected. The frequency with which infants regurgitate food, and their inability to keep the nasopharynx clean may also play a part. Some cases of otitis can be attributed to forcing nasal secretions up into the middle ear; this may occur during nasal irrigations, particularly if improperly done; simultaneous compression of both nostrils in blowing the nose may do this in older children.

The bacteriology of acute otitis varies in different localities, and in different years even in the same locality. In Baltimore, hemolytic streptococci have played



the most important part. In the series studied by Smith, these organisms were found in the great majority of cases, even those complicating pneumococcus pneumonia and diphtheria. These organisms sometimes spread with great rapidity from one individual to another in spite of any precautions that may be observed. In hospitals for infants where many of the patients are poorly nourished, streptococcus otitis may spread like any contagious disease. Any of the pyogenic bacteria may give rise to acute otitis—other varieties of streptococci, staphylococci, pneumococci, and influenza bacilli; organisms of the colon group are not uncommon offenders. Diphtheria bacilli, Vincent's organisms, meningococci, *B. pyocyaneus* and a variety of other organisms are occasionally found. Cases due to the tubercle bacillus are considered elsewhere. Cultures made by aspirating pus with a needle through an unruptured bulging drum almost invariably yield a pure culture of some one organism. Cultures made from a discharge that has persisted for some days are often mixed; bacteria entering from the external auditory canal doubtless cause secondary infection.

**Pathology.**—Inflammation of the middle ear is found in all degrees of severity. If the ear drums are examined during a common cold some congestion of the vessels along the manubrium of the malleus and perhaps of Shrapnell's membrane is often found; such a condition scarcely deserves to be called otitis media.

With a true *catarrhal otitis media* there is swelling and congestion of the mucous membrane of the eustachian tube, causing more or less obstruction of that passage; the inflammation extends to the lining of the entire tympanic cavity. The drum becomes intensely injected, but retains its normal contour. If embryonic tissue persists in the tympanic cavity, this too becomes congested and hyperemic. In some instances the process does not progress beyond this stage; in others the inflammation continues. There is exudation, first of serum, then of mucopurulent material and finally pus; obstruction of the eustachian tube causes these secretions to accumulate in the middle ear; the drum bulges and may rupture. In most cases of *purulent otitis media* the inflammation is confined to the mucous membrane. The pus may be absorbed if the process subsides, or it may be released by spontaneous rupture or paracentesis. In either case healing is usually complete, no defect of hearing persisting.

A more destructive form of otitis is sometimes seen. This is particularly frequent in the cases complicating scarlet fever, but it may be met with in measles and other conditions. The infection is a very virulent one (*phlegmonous otitis*) and attacks not only the mucous membrane and embryonic tissue of the tympanic cavity, but extends to the fibrous and bony tissue as well. Extensive sloughing of the tympanic membrane may occur. The ossicles and any part of the bony lining of the middle ear cavity may be affected. Chronic otitis not infrequently follows this condition. After the infection has cleared up, it is usual to find some permanent damage to the auditory apparatus in the form of destruction of large areas of ear drum, adhesions between the ossicles and the walls of the tympanic cavity and adhesions about the fenestra of the labyrinth. Contrary to the general impression, deafness following scarlet fever is not caused by destruction of the ear drum, but is due to disease of the labyrinth. If the labyrinth, the oval window



and the stapes are intact, hearing may be excellent even with complete absence of the drum.

The complications of acute otitis—disease of the mastoid, the various forms of chronic otitis, and the results of extension of the inflammatory process to the bones and nervous system—are discussed below.

**Symptoms.**—In a typical case in an infant, there is generally at the beginning some evidence of rhinopharyngitis and perhaps a temperature of 100° to 102° F. After a day or two the symptoms in the nose and throat may subside, but the temperature remains elevated, usually between 100° and 103° F.; it may be 104° or more. The infant continues to be restless, fretful and sleeps poorly; he seems decidedly ill and yet no very definite symptoms are present. Local symptoms are

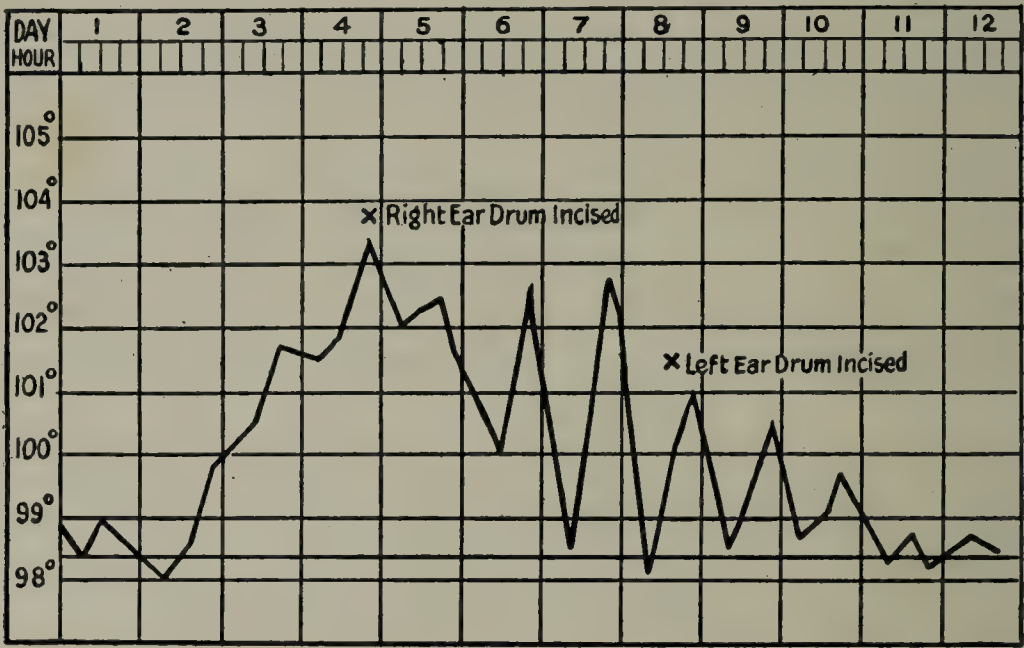


FIG. 48.—TEMPERATURE CHART OF UNCOMPLICATED ACUTE OTITIS MEDIA FOLLOWING RHINOPHARYNGITIS, IN A CHILD THREE YEARS OLD.

rarely definite in infants and often are absent altogether. Sometimes the child shows signs of pain when the ear is touched; he may refuse to lie on one side. Sometimes an infant will put his hand to the ear frequently. After several days during which the temperature runs an irregular course rupture of the membrane may occur and the fever and other symptoms subside. After spontaneous rupture or incision the fever decreases but seldom drops to normal at once; more often it tapers off during the course of two or three days; it may persist because of infection elsewhere (see Fig. 48).

Great variations are seen in the local and constitutional symptoms. In some cases the nervous symptoms may be marked and there may be convulsions. Fever in some cases may be as high as 105° F.; in other instances, notably in marantic infants, the disease may run its course without any elevation of temperature, a purulent discharge being the first indication of its presence. Cases which complicate acute infectious diseases are not apt to be recognized before perforation takes place unless the drums are examined regularly.

In older children pain is usually sharp and severe and is complained of early in the attack. The intensity of the pain, however, is no indication of the severity of the process. Sometimes during ordinary head colds there are seen cases with severe pain in the ear, lasting for twenty-four or thirty-six hours, with only



slight injection of the drum. In other cases the drum may rupture and yet pain may not have been great. Pain is thought to be more marked in older children and adults because the drum in later life becomes firmer and yields less readily to pressure. Older children with otitis sometimes complain of tinnitus; there may be marked tenderness to pressure in front of the meatus, occasionally over the whole side of the head. Hearing is impaired to some extent during the acute stage.

**Diagnosis.**—Examination of the ear drums with a magnifying otoscope should be made as part of every routine physical examination. It is an excellent rule to defer an opinion on the state of the drum until all wax has been removed from the canal so that the drum can be seen in its entirety. Wax is rarely so adherent that it cannot be removed with a curet; occasionally a preliminary syringing with warm water to soften the wax is required. The drum is best viewed by pulling the auricle upward and backward to straighten the external canal while inserting the otoscope speculum. In judging its appearance one must be familiar with the normal picture.<sup>1</sup> A number of pathological appearances are met with. Slight injection of the vessels along the manubrium of the malleus accompanies almost every common cold. It may result from crying alone. Localized areas of congestion may be traumatic, from the removal of impacted wax. In the early stage of an acute otitis there is diffuse congestion of the entire drum, the process being most intense in the upper posterior portion. Owing to this congestion and edema the drum is actually several times as thick as a normal drum, a fact which can scarcely be appreciated otoscopically. Edema, however, causes the drum to lose its luster, and the cone of light is dimmed. At this stage there is no bulging and the bony landmarks are still distinct (Plate IIB). Later, when the tympanic cavity becomes filled with secretions, the drum begins to bulge; this occurs first in the upper posterior portion, the bulging gradually advancing forward. The bony landmarks and the cone of light are soon obliterated. The bulging area does not usually spread beyond the point shown in the illustration, although it may be very marked in the posterior and upper portion of the drum (Plate IIC).

To the trained eye there is little difficulty in recognizing a bulging drum; the most common error the novice is likely to make is in confusing the posterior wall of the canal with an injected, bulging drum. Such a mistake may occur if the canal is not completely cleaned out and only a partial view of the drum is obtained. It is not possible from the otoscopic appearance to determine the cause of the bulging. If it is extreme, one can be reasonably sure that pus is present; lesser degrees of bulging may be due to pus, to serous or mucoid secretion or to hemorrhage within the drum. Occasionally congestion and swelling of the posterior portion of the drum are so great that some bulging is evident otoscopically, although there may be no increased pressure in the tympanic cavity. Localized serous

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<sup>1</sup> The drum of the normal infant is less transparent than in later life; the central fibrous layer is less well developed, but the internal mucous lining is much thicker. The characteristic bony landmarks can, however, be easily seen. The most conspicuous landmark is a pale circular projection caused by the *short process* of the malleus. From this point, two folds—one passing forward, the other upward and backward—divide the drum into a smaller upper portion, the *pars flaccida* (Shrapnell's membrane) and a larger lower portion, the *pars tensa*. Extending downward and backward from the short process is a definite ridge caused by the *manubrium* (long process) of the malleus, which terminates at a point near the center of the drum (*the umbo*). Below the umbo the drum is concave and gives rise to a triangular reflection, the *cone of light*. (Plate IIA.)



or hemorrhagic vesicles are sometimes seen on an inflamed drum; they have no special prognostic or therapeutic importance.

If a discharge is present in the external meatus, there can be little doubt that it originates from otitis media; a furuncle opening into the external canal is accompanied by great local pain. In some patients with a severe weeping eczema involving the canal, it may be difficult to decide whether the discharge comes from the middle ear or represents merely oozing from the skin; not infrequently this type of discharge is accompanied by a foul odor, as in neglected cases of middle ear disease. The discharge from otitis is much more profuse and often contains bubbles of air.

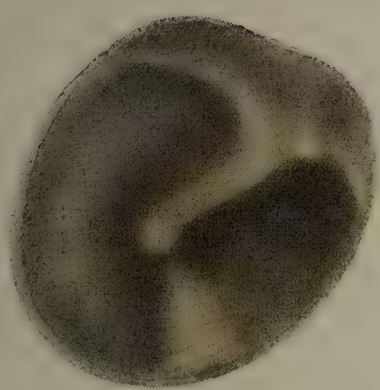
**Treatment.**—In the early stage where only congestion of the drum is present, the indications are to relieve the pain and if possible to keep the eustachian tubes open and prevent damming back of the secretions in the middle ear. The pain of otitis may be relieved to some extent by the application of dry heat to the ear or by the instillation of drops of 5 or 10 per cent carbolic acid in glycerin in the external meatus. A sedative may be advisable; in rare instances the pain may be so acute even without bulging of the drum that a few drops of novocaine applied to the drum may be required. It is debatable how much can be accomplished in the congestive stage in the way of aborting an attack of purulent otitis by intranasal applications of epinephrine or ephedrine to dilate the eustachian orifices; however, it seems likely that this may sometimes be effective. A few drops of 1:5000 solution of epinephrine or a 2 per cent solution of ephedrine may be instilled into the nose with the head held back, several times a day.

The question of when to incise a drum is not easily answered. On general surgical principles it is logical to suppose that relieving the pressure in the tympanic cavity will tend to prevent the spread of the infection within the ear; however, there is also the possibility that the middle ear may be secondarily infected after incision by bacteria from the external canal. An intensely bulging drum should always be opened without delay; such a drum is likely to rupture spontaneously and much less damage to the drum is done by incision than by rupture; moreover, the drum heals more rapidly. In opening drums which are only moderately bulging, one should be guided by the extent of fever and pain; the bulging in such cases will often subside spontaneously. Sometimes a close examination of the bulging part of the drum will reveal minute wrinkles which reflect the light; this may be taken as an indication that the drum has previously been more distended and that in all likelihood the process has begun to subside; in such cases incision may well be postponed. If there is any evidence of mastoid infection, early free incision of the drum is indicated. The same may be said of otitis accompanying scarlet fever; the danger of complications is so great in scarlatinal otitis that it is unwise to delay myringotomy.

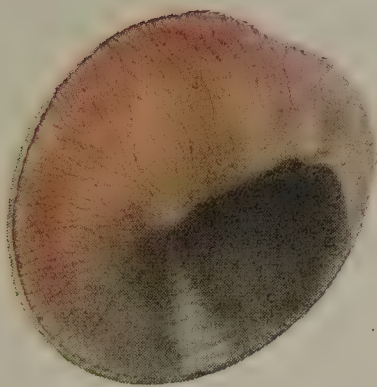
In infants incision of the drum requires no anesthetic. With children over two years old a local anesthetic is indicated; a few drops of a 5 or 10 per cent solution of novocaine in the canal will usually give a satisfactory anesthesia. General anesthesia is rarely necessary. The incision should be made in the mid-posterior portion of the drum, at the point of maximum bulging; a linear incision rather than a stab should be made, otherwise the opening is apt to close prematurely. The knife



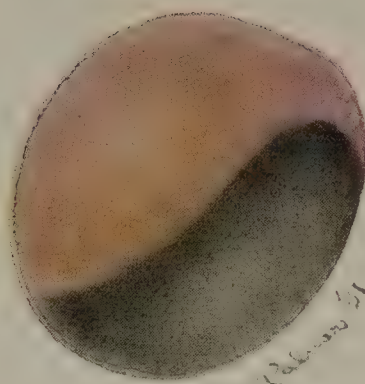
## PLATE II



A



B



C

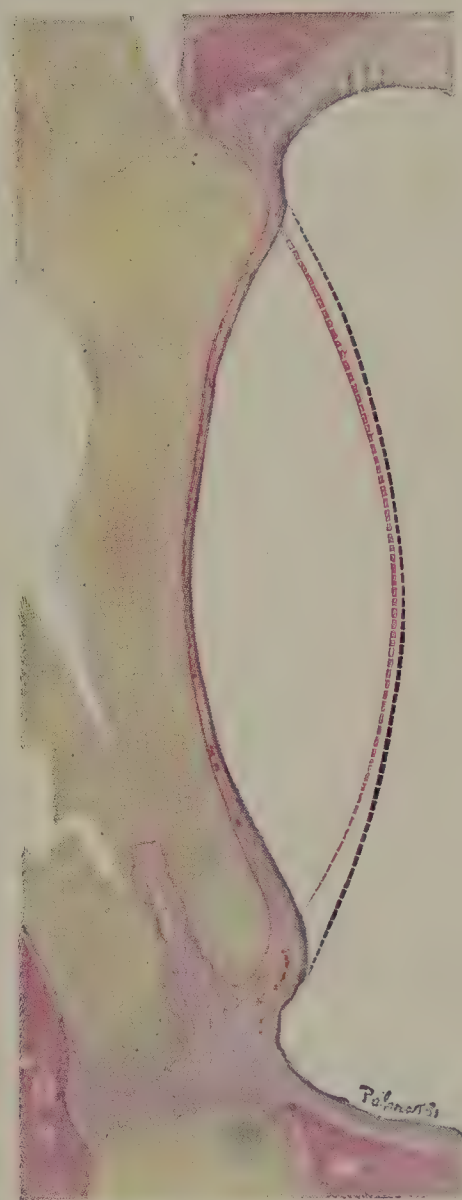
*W. C. Calkins '51*



D



E



F

*Politzer*

### NORMAL EAR DRUM AND TWO STAGES OF ACUTE INFLAMMATION.

A, B, C, the drum as seen through a speculum.

D, E, F, histologic sections.

A and D, normal ear drum

B and E, catarrhal otitis media with beginning bulging; landmarks still visible.

C and F, acute purulent otitis media with marked bulging of the drum. In C the landmarks are obliterated. In F the dotted lines indicate the position of the drum during life, the shrinkage to the position shown in the drawing having occurred in the process of fixation.







should penetrate the entire thickness of the drum and should be carried downward in a curving incision that avoids the malleus and ends at the lower part of the drum.<sup>2</sup> The puncture may yield serum which is tinged with a variable amount of blood; it may yield mucopurulent material or pus. A discharge of bloody serum may be due to the fact that the drum has been incompletely punctured. An inflamed drum is usually many times as thick as a normal drum and is much more vascular, as may be seen from the illustration. A considerable amount of bloody serum may be obtained from the central layers of the drum itself. In such cases, a deeper puncture may yield clear serum or pus. A bloody serous discharge may, however, come from the middle ear itself. In some instances in which considerable embryonic tissue persists<sup>3</sup> in the middle ear, bloody serum is obtained when this is incised through the drum. With extreme bulging of the drum, the membrane becomes compressed and thinner; one is less likely to make the mistake of incomplete paracentesis.

After incision or rupture of the drum, the ear should be irrigated several times a day. We use hydrogen peroxide for this purpose; it is best applied by means of a rubber-tipped medicine dropper, the ear being irrigated with fresh material until the peroxide no longer froths. Irrigation removes pus which may otherwise block the canal; it is of particular value when the secretions are thick and viscous; with a thin profuse discharge its value is questionable. If antiseptics are to be used, they must of course be preceded by careful irrigation if they are to penetrate into the middle ear. We are inclined to limit their use to chronic cases. After irrigation the canal should be dried carefully to prevent maceration and the development of eczema. A plug of absorbent cotton may be placed in the external meatus, not so tightly as to cause obstruction; its purpose is to absorb the discharge and prevent excoriation of the pinna; with a profuse discharge this must be frequently changed.

The character of the aural discharge may change after paracentesis; a serous discharge often becomes purulent after twenty-four or thirty-six hours. This does not necessarily indicate a secondary infection, but may be merely the natural course of the disease. In most acute cases the discharge ceases in from one to three weeks. The drum sometimes shows a tendency to close prematurely and must be reopened more than once. If the discharge persists, the measures mentioned under chronic otitis may be tried.

**Complications and Sequelæ.**—Infection of the mastoid antrum is so frequent as to be considered an accompaniment rather than a complication; it occurs in every severe case. Other complications which may occur in acute otitis represent extension of the infection from the mastoid antrum or the middle ear to adjacent structures. Subperiosteal abscesses, labyrinthitis, sinus thrombosis, meningitis, chronic osteomyelitis, facial paralysis and brain abscess may follow. Erysipelas or impetigo may start from the excoriation caused by an aural discharge.

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<sup>2</sup> If the incision is made too high damage to the ossicles is a possibility. Perforation of the jugular bulb has occurred from incisions made too low in the posterior part of the drum.

<sup>3</sup> The persistence of embryonic mesenchymal tissue in the middle ear is by no means confined to the first days of life, as is often stated. Although some pneumatization of the tympanic cavity during the first few days occurs regularly, a variable amount of the gelatinous embryonic tissue may be found even in adult life. Crowe and Polvogt have observed it in subjects fifty years old.



As a rule, acute otitis leaves no permanent defect of hearing. Bunch and Grove in a follow-up study of 160 ears which had suffered from severe acute otitis some years before were able to demonstrate defects of hearing in only 19 per cent of these. In spite of normal hearing, however, otoscopic evidences of former disease were present in many instances; these consisted of abnormal retraction of the drum, scarring, folds and calcified plaques. Pneumatization of the mastoid was not infrequently interfered with.

**Prophylaxis.**—Much can be done to prevent the recurrence of acute attacks of otitis by attention to chronic foci of infection in the nose and throat, particularly adenoids. Any of the measures discussed in the prevention of common colds are of help.

### CHRONIC OTITIS MEDIA

An aural discharge which persists more than three weeks may well be regarded as chronic. The cause of its persistence may be inadequate drainage, sometimes a focus of infection in the nasopharynx such as adenoids. When the process has spread to the bony structures, a chronic osteomyelitis may be responsible for keeping up the discharge. The state of the patient's nutrition is often a factor in chronic infections.

In many cases of chronic otitis a mixed infection is present. Putrefying organisms may cause secondary infection and give rise to a fetid discharge. *B. pyocyaneus* is a not uncommon invader. Some cases of chronic otitis are tuberculous in origin.

There is a thickening of the mucous membrane lining the tympanic cavity; in many places granulations are found and there may be polyp formation. There is more or less extensive destruction of the drum, which shows little tendency to heal, and as a rule some impairment of hearing. The process is not accompanied by pain. An offensive odor to the pus or the presence of pyocyaneus infection with its characteristic odor are often found with bone destruction, but are sometimes met with in uncomplicated cases. If there is facial paralysis, this is an indication of involvement of the bone in the region of the facial canal.

If an aural discharge fails to clear up in three weeks, the use of antiseptics may be given a trial. The ear must be thoroughly irrigated and the canal completely freed from pus before the antiseptic is introduced; otherwise it will not reach the middle ear. Dyes have some effect in eliminating the secondary invaders; gentian violet and mercurochrome in 1 per cent aqueous solutions may be used on alternate days; a few drops are introduced after each irrigation. In the presence of a pyocyaneus infection nothing is so effective as a 2 per cent solution of acetic acid. If results are not obtained within a week or two the question of removing adenoids or other possible foci of infection should be taken up; hypertrophied adenoids should be removed.

Should the discharge continue in spite of these measures, postauricular drainage through the mastoid antrum or a more radical mastoid operation may be indicated. The treatment of chronic otitis is the province of the otologist rather than the pediatrician.



**Tuberculous Otitis.**—It may be impossible to distinguish this clinically from any other variety of chronic otitis. It is usually found in conjunction with an active pulmonary process, but not invariably so; apparently it is sometimes hematic in origin. Irregular perforations of the drum are often tuberculous; multiple perforations are nearly always so. There is usually bone involvement; tuberculosis is the usual cause of facial paralysis accompanying otitis, and should be suspected whenever this complication is present. The discharge in tuberculous cases is nearly always secondarily infected, often with pyocyanous organisms. Tubercle bacilli cannot always be demonstrated in smears, but can usually be recovered by animal inoculation.

**Cholesteatoma.**—This is a comparatively uncommon form of chronic otitis which results from ingrowth of squamous epithelium from the external meatus into the tympanic cavity. Such ingrowth of epithelium takes place only after destructive forms of acute otitis, usually following scarlet fever, in which the mucous membrane lining the middle ear has become ulcerated. The squamous epithelium covers the ulcerated portions of the mucosa of the middle ear and may extend into the mastoid, or in fact to any portion of the temporal bone. The characteristic features of the condition are caused by the tendency of squamous epithelium to invade the underlying structures in deep processes or crypts, and by the continual desquamation of this epithelium. When these crypts are not too deep the desquamating epithelium is discharged in the form of white flakes, visible in the aural discharge. In other regions the desquamated epithelium may become walled off and cannot then be discharged from the surface; it collects in the form of dense chalk-like deposits which steadily increase in size. Pressure of these tumor-like masses causes erosion of the bone, and extension of the process may give rise to serious labyrinthine or meningeal symptoms.

The condition is recognized clinically by the white flakes in the aural discharge, and by the presence of a marginal perforation of the drum, usually in the upper posterior quadrant; there may be complete destruction of the drum. It is almost always bilateral. Although, as Polvogt has shown, the invasion of squamous epithelium may be found as early as five days after perforation has taken place, it requires several weeks before the condition is well developed. The treatment is surgical.

## MASTOIDITIS

At birth the mastoid process is undeveloped. There exists but a single cavity in the bone in this region, the *mastoid antrum*, which is continuous with the superior part or *attic* of the tympanic cavity. Like the tympanic cavity, the mastoid antrum is filled at birth with gelatinous embryonic mesenchymal tissue. Pneumatization of the antrum begins shortly after birth, but areas of embryonic tissue may persist for a long time, sometimes throughout life. The mastoid process begins to grow during the first year, but the development and pneumatization of the mastoid cells varies greatly in different subjects and is ordinarily completed some time between the fifth and tenth years.

The mastoid antrum is infected in the great majority of cases of acute otitis media, certainly in all the more severe cases, but this produces no particular symp-



toms. In purulent cases drainage takes place through the ear and is, as a rule, satisfactory. The diagnosis of mastoid disease is not made in such instances, or at the most can only be suspected with an unusually profuse discharge. Symptoms calling attention to the mastoid are met with only when drainage through the middle ear is inadequate, or when for some other reason the process spreads from the mastoid antrum to the surrounding structures. Inadequate drainage through the ear may occur when the pus is very thick and does not flow well; it may occur when the passage between the antrum and the tympanic cavity—the *aditus ad antrum*—is obstructed by granulations or infected embryonic tissue. Mastoid symptoms may occur when there has been no perforation of the ear drum. Primary mastoiditis<sup>4</sup> of hematogenous origin is said to develop occasionally; we have never seen it. The bacteriology of mastoiditis is similar to that of otitis media.

Symptoms of inadequate drainage of the mastoid may occur during the latter part of the first week of an acute otitis, or at any time thereafter; an abscess is rarely met with before the second or third week. The characteristic symptoms are postauricular edema, pain and tenderness over the mastoid, and sagging of the posterior wall of the external meatus due to edema. The infection may rupture through the bone covering the antrum and give rise to a subperiosteal abscess; in infants a subperiosteal abscess may form without rupture of the bone, by extension along the squamopetrosal suture which is still patent. With a subperiosteal abscess there is marked postauricular swelling and redness; the ear stands out from the head quite prominently. The mastoid antrum sometimes ruptures inward, giving rise to sinus thrombosis or meningitis. Rupture of the antrum is sometimes accompanied by a sudden drop in temperature or by sudden diminution of the aural discharge, the drum remaining open.

Postauricular drainage of the mastoid antrum—*antrotomy*—is a very simple operation in infants; when the mastoid process and the cells are well developed it becomes more difficult.

There can be little doubt that mastoiditis was neglected by pediatricians in the past. At the present time we are inclined to think that the pendulum has swung in the other direction, and that postauricular drainage is often unnecessarily performed. The indications for a mastoid operation are a temperature (otherwise unexplained) remaining high after myringotomy, with a thick discharge which does not drain well; also any swelling, redness or tenderness over the mastoid. A rising leukocytosis otherwise unexplained gives added weight to the possibility of an undrained mastoid infection. Little information is to be derived from an x-ray in regard to acute disease. A mastoid swelling is sometimes confused with an abscess originating from a superficial lymph node, but if fluctuation is present, the mistake is of little significance.

In chronic otitis, mastoidectomy is sometimes performed as a last resort when other measures have failed. The operation carries with it very little risk; if carelessly done the incus may be dislocated. The wound heals by granulating up from the base, this usually requiring from three to six weeks.

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<sup>4</sup> One should be cautious in accepting cases in which the diagnosis rests upon the finding of pus in the mastoid antrum at autopsy, in the absence of clinical symptoms during life. Beyond a doubt the presence of gelatinous embryonic tissue in the antrum, and in the middle ear as well, has often been mistaken for pus.



## LABYRINTHITIS

Disease of the labyrinth may be congenital in origin; a great variety of malformations and defects of development are met with. It may result from mechanical or acoustic trauma; excessively loud noises may cause temporary changes or permanent degeneration of the hair cells of the organ of Corti. Degeneration of the acoustic and vestibular nerves may be the result of intracranial lesions; there is also seen a toxic neuritis following infectious diseases. In the majority of instances, however, disease of the labyrinth is inflammatory in origin. It may represent extension of a middle ear inflammation, extension from the meninges, as in meningococcus meningitis, or in some instances it may be hematogenous.

Involvement of the cochlea produces deafness, sometimes tinnitus. Vestibular disease is manifested by vertigo, nystagmus, nausea and vomiting. The special tests for the accurate diagnosis of defects of hearing and of vestibular lesions belong to the domain of the otologist rather than the pediatrician.

## DEAF-MUTISM

Deaf-mutism may be either congenital or acquired; most cases belong to the latter group. Congenital deafness may depend upon mental defects or brain lesions, abnormalities of the auditory nerve and a great variety of malformations or defects of the internal ear. Many cases are familial and hereditary. An unusual form of congenital deafness is associated with endemic goiter, in which bony changes about the oval window and hyaline masses between the organ of Corti and the tectorial membrane are present; this rarely causes complete deafness.

Acquired deaf-mutism is usually the result of extension of middle ear disease to the labyrinth; scarlet fever is the most common cause. The second important cause is meningococcus meningitis, in which there may be direct extension of the meningeal inflammation to the labyrinth. Any inflammation of the labyrinth may be responsible. Neuritis of the acoustic nerve may follow acute infectious diseases—mumps, diphtheria, influenza, syphilis, etc.

If deafness develops before the fifth year, speech is usually lost; the younger the child, the more rapidly does this occur. Total deafness is rare among deaf-mutes; according to Love, hearing by bone conduction is present in nearly all cases; about 25 per cent have a useful degree of hearing by air conduction. Labyrinth tests should be performed in all cases: if no vestibular response is elicited, deafness is generally total; but if a normal vestibular response is obtained, there may or may not be complete deafness.

The technic of reëducating the deaf-mute has been greatly advanced in recent years by means of instruments specially designed to educate the sense of touch. When the vocal sounds are sufficiently amplified and transmitted to a suitable receiver upon which the finger tip rests, the subject soon develops the ability to discriminate between words. Franklin has shown that the process of reëducation may with advantage be commenced even in infancy. With the aid of such apparatus he has been able to develop speech and lip reading to such an extent that deaf-mutes five and six years of age may enter and progress normally in public schools.



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## CHAPTER XLI

### DISEASES OF THE LARYNX

The larynx in infancy differs in some respects from that of later childhood and adult life. The upper portion is relatively narrower laterally; the cartilages are softer and the walls more readily compressible; the mucous membranes are said to be more vascular. It is a striking peculiarity of the infant's larynx that reflex spasm is excited with great ease; the cause for this is obscure.

#### CONGENITAL MALFORMATIONS

A number of malformations of the larynx and its surrounding structures may give rise to a clinical picture which is fairly definite and passes under the name of *congenital laryngeal stridor*. The symptoms are not present at birth, but usually begin during the first week of life. There is an inspiratory stridor which may be very pronounced and accompanied by recession of the soft parts of the chest wall, yet there is usually no cyanosis or subjective distress, and the child appears comparatively comfortable. Expiration is easy and the voice and cry are normal. The stridor becomes more intense with excitement and crying; there may then be cyanosis and marked dyspnea; it diminishes when the child is quiet but usually does not entirely disappear even during sleep.

These symptoms may increase for the first few weeks; they then become stationary. After the first six months with the growth of the larynx the stridor tends to diminish. By the end of the second year it is usually gone or heard only on occasion.

In many of the reported cases there have been found malformations, especially of the epiglottis, which narrow the opening of the larynx. Sometimes there is a web-like membrane which partially occludes the orifice. In some instances the stridor is produced by lax aryteno-epiglottic folds of mucous membrane which tend to occlude the glottis; this has been attributed to defective innervation and to a redundant mucous membrane. Congenital stridor is favored by the collapsible character of the infant's larynx; minor causes which do not affect an older child or adult produce obstruction in infants. In some cases the cause can be attributed to pressure outside the larynx, most commonly from an enlarged thymus; in such instances radiation of the thymus with x-ray may cause disappearance of the symptoms.

An interesting group of cases is associated with hypoplasia of the mandible. The child has a recessive chin; the stridor in these cases is not produced within the larynx, but apparently by the tongue, which has a tendency to fall backward and interfere with the entrance of air into the larynx. In a case of this kind reported by Lenstrup the stridor could be made to disappear by keeping the child upon his face, propped between pillows.



The prognosis in most of these congenital cases is good, the chief danger being from intercurrent pneumonia. Marked deformities of the thorax may be produced, but these are rarely permanent.

Congenital stridor must be distinguished from inflammatory conditions of the larynx associated with spasm, from obstructive laryngitis, from laryngismus stridulus (tetany) and from papillomata. In inflammatory conditions and with neoplasms the voice is always affected; in the former there are local and perhaps constitutional evidences of an inflammation. In tetany the attacks are intermittent. The history in most of the congenital cases is characteristic. Pharyngeal obstruction can be ruled out by the fact that the dyspnea is not increased by closing the mouth. The nature of the obstruction is often revealed by laryngoscopy.

Special treatment is rarely required; most cases clear up spontaneously in the course of time. Tracheotomy may be performed if the dyspnea reaches an alarming degree. The indications are to maintain the child's nutrition and to protect him from upper respiratory infections.

### CATARRHAL SPASM OF THE LARYNX

Spasm of the larynx (spasmodic croup) may be the manifestation of a general disorder, as in the laryngismus stridulus of tetany. It may be associated with inflammations of the larynx and adjacent structures; it is particularly characteristic of pertussis, and gives rise to the characteristic "whoop" of that disease.

Young children between the ages of six months and three or four years appear to be particularly susceptible to spasm of the larynx. Most of these cases are inflammatory in origin, but the evidences of inflammation may be so mild as scarcely to attract attention, the symptoms of spasm dominating the picture. In some cases there seems to be a hereditary predisposition to attacks of spasmodic croup. Exposure to cold and gastro-intestinal disorders may also be predisposing factors. The condition is more common in children with enlarged tonsils and adenoids, probably because of the increased tendency to inflammation of the upper respiratory passages. There is little doubt that spasm of the larynx is less frequently seen now than formerly; the reason for this is not clear.

**Symptoms.**—The attack may be preceded for several hours by slight hoarseness, or by the evidences of a rhinopharyngitis. During the day the child may appear perfectly well. Usually there is heard during the evening a hollow, barking cough, at first infrequent and not severe. About midnight this is apt to increase in severity, and there is now difficulty in breathing. As soon as this becomes marked the child wakes, and presents the characteristic symptoms of an attack. In the mild cases the dyspnea is not sufficient to waken the child. In severe cases there is marked dyspnea, especially on inspiration, and a loud stridor as the air is drawn through the narrowed opening of the glottis. This may often be heard in an adjoining room. There is seen on inspiration deep recession of the suprasternal fossa, the supraclavicular spaces, and the epigastrium; also depression of the intercostal spaces, and even of the walls of the chest. Any excitement increases the spasm and aggravates the dyspnea. The distress may be great; the breathing usually slow and labored; the voice hoarse, but rarely lost; the cough stridulous, hoarse, and metallic; the pulse rapid; the temperature normal or slightly elevated,



rarely over 101° F. There may be slight cyanosis of the finger-tips and of the lips, and sometimes considerable prostration. In the course of three or four hours the attack slowly wears away and the child falls asleep. During the following day, aside from slight hoarseness and occasional cough, he is apparently well. Most of the cases are not so severe as this; there is croupy cough, hoarseness and general discomfort, but not marked dyspnea. On the second night there is a repetition of the experience of the first, usually quite as severe unless affected by treatment; and on the third day a remission similar to that of the day previous. On the third night the attack, if it occurs at all, is generally a mild one. Slight hoarseness persists for several days, but otherwise the child is apparently well. Some children have such attacks every few weeks in the course of the cold season, the slightest exposure or an indiscretion in diet being sufficient to induce one.

**Prognosis.**—This is good, the condition not proving fatal, although nothing is more alarming, at least to parents, than to witness for the first time one of these severe attacks of catarrhal croup.

**Diagnosis.**—Catarrhal spasm of the larynx must be distinguished from tetany, and also from conditions in which the laryngeal obstruction is due to inflammatory products rather than spasm—notably laryngeal diphtheria. Tetany is not associated with cough and hoarseness, and has its own special diagnostic signs. From the more severe forms of acute laryngitis and laryngeal diphtheria, catarrhal spasm is distinguished by its sudden onset, the mildness of the symptoms of inflammation, the spasmodic character of the dyspnea, and the diurnal remissions. The stridor of spasm is usually confined to inspiration. The history of previous attacks will often aid in diagnosis. In case of doubt, a positive diagnosis can often be made by allowing the child to inhale a little ether. This at once relieves dyspnea due to spasm, while it has scarcely any effect upon that due to inflammation or membrane.

**Treatment.**—The purpose of treatment during the attack is to produce relaxation of the laryngeal spasm. This is accomplished by the use of emetics, steam, and hot fomentations over the larynx. To produce vomiting, ipecac is the safest drug. This may be given in the form of the syrup, one-half teaspoonful every ten or fifteen minutes to a child of two years until vomiting occurs. The latter should not be repeated more than once or twice as it may produce serious depression. When given at longer intervals these remedies are useful in relaxing spasm without causing emesis.

Emetics have a double value if the attack is due to indigestion. Following free vomiting there is generally some improvement in the symptoms, but there may be a recurrence of the spasm unless other means are employed. To prevent this, antipyrine is one of the most useful drugs. One grain may be given to a child one year old. This may be repeated every two hours if necessary. Luminal, in doses of  $\frac{1}{8}$  to  $\frac{1}{4}$  grain, is also valuable. Quite as much relief as that obtained from the drugs mentioned is seen from the use of steam inhalations. For this purpose the child should be placed in a closed tent, and steam introduced from a croup kettle. This may be used in conjunction with other measures, and continued as long as necessary. Hot applications over the larynx are also useful. In one case in which severe spasm had recurred for eight successive nights in spite of every-



thing that was tried, the child being in great distress from the dyspnea, intubation was performed with instant relief.

During the day following the first night attack, the child should be kept in a warm room, and it is well to continue the ipecac in doses too small to produce vomiting. After 6 P.M., the doses should be doubled, and at bedtime either antipyrine or luminal given. If so treated, the symptoms may not recur upon the second night, or there may be only the cough without the severe dyspnea. The child should be confined to the house for two or three days after one of these attacks, the drugs being gradually reduced; but the antipyrine or luminal should be given at bedtime for three or four successive nights.

The prevention of attacks involves such hygienic measures as may be of value in preventing common colds; hypertrophied tonsils and adenoids may require attention. Although fresh air is desirable, cold air at night should be avoided, particularly in the presence of any upper respiratory infection.

### ACUTE LARYNGITIS

Acute laryngitis occurs as one of the manifestations of the common cold; as such it may be primary or may result from downward extension of a process in the pharynx. The laryngitis of diphtheria is considered elsewhere. Acute laryngitis is frequently caused by pyogenic organisms; this is probably the case when it occurs as a complication of measles, scarlet fever and other infectious diseases; it is also the case in some instances of primary laryngitis. Exposure and chilling would seem to be predisposing factors<sup>1</sup>; most attacks occur during the winter season. In rare instances acute laryngitis may be of traumatic origin, from the inhalation of steam or irritating gases.

Acute laryngitis may occur at any age; it is more common between the first and the fifth year, and it is in these young children that the severer forms are met with.

**Pathology.**—There may be merely congestion of the mucous membrane, general or localized. This can be seen with the laryngoscope, but is not always visible after death. With the congestion there are swelling and dryness, followed by increased secretion. In the milder cases the process is limited to the mucosa. In the more severe cases it involves the submucosa also, which is congested, edematous, and may be infiltrated with cells. The changes are especially marked in the lymphoid tissue of the subglottic region. In the most severe cases, which are usually due to beta-hemolytic streptococci, there may be a membranous laryngitis indistinguishable microscopically from that of diphtheria; such instances are, however, not common. The degree of laryngeal stenosis produced is variable; in mild cases there may be very little unless spasm is present; in the more marked cases stenosis may be extreme. Tracheitis and bronchitis are usually associated with the severer cases. In young children, there is little tendency to edema of the glottis.

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<sup>1</sup> The following case is a good illustration of a severe attack, apparently excited by cold: A rather delicate infant, eight months old, was taken out, with very scanty covering, on a raw December day. In a few hours hoarseness and stridor were noticed, and the temperature was 101° F.; three hours later it was 103° F., and in spite of the usual remedies which were employed the dyspnea had reached such a degree as to require intubation. The tube was worn only three days and the child made a prompt recovery.



**Symptoms.**—The evidences of catarrhal spasm are likely to be found in any case of acute laryngitis—mild or severe—particularly in young children. In the mild form, such as that which is usually seen in older children, there is hoarseness, or even loss of voice, and a laryngeal cough which is sometimes hard and teasing and always worse at night. There may be pain and soreness over the larynx. Constitutional symptoms are mild or absent, the patient not usually being sick enough to go to bed, and often rebelling even at being kept indoors. The duration of the disease is from four to ten days, with a strong tendency to relapses from slight causes.

In severe forms there may be mild laryngeal symptoms for a few days before the development of the more severe ones. In other cases the disease develops rapidly and severe symptoms are present within a few hours from the onset. Constitutional symptoms are usually prominent. The temperature may go to 104° or 105° F. The pulse is rapid and full and respiration is accelerated. Children sometimes complain of pain in the larynx and trachea, which is increased by coughing. The voice is invariably modified, often lost; dyspnea and stridor are expiratory as well as inspiratory, and persist through the day as well as by night. There may be enlargement of cervical glands. The symptoms are severe for two or even three days, the fever continuing with moderate prostration and paroxysms of dyspnea, sometimes even attacks of suffocation and cyanosis. Usually after two or three days there is a gradual subsidence of the dyspnea and the inflammatory symptoms, and the case goes on to recovery. At other times, and this is especially likely to happen in children under two years of age, the inflammation extends downward to the large and then to the small bronchi, and finally results in pneumonia. The attack may prove fatal from laryngeal obstruction caused by edema, by spasm and rarely by the presence of membrane.

**Diagnosis.**—Diphtheria must always be kept in mind with any case of acute laryngitis; a throat culture should not be omitted. Although the onset of diphtheria is usually more insidious and the constitutional symptoms relatively less marked, it is often impossible to distinguish diphtheria upon clinical grounds. If disease is confined to the larynx, a negative throat culture is sometimes obtained; it is therefore advisable in all severe cases of laryngitis to make direct cultures from the larynx if the throat culture has failed to show Klebs-Löffler bacilli.

**Prognosis.**—This depends upon the severity of the disease and the age of the patient. It is better in children over three years of age than in infants, also when the general condition of the child is good. The prognosis in severe cases should always be guarded; it is impossible at first to be certain that the case is not one of laryngeal diphtheria. The rare cases of membranous laryngitis due to streptococci and staphylococci are quite as much to be dreaded as true diphtheria; perhaps more so, since no specific therapy is available.

**Treatment.**—In all cases children affected are to be kept in bed, and the temperature of the room should be approximately 70° F. The diet should be light and fluid. Antipyrine (1 grain every two hours to a child two years old) or luminal sodium ( $\frac{1}{8}$  to  $\frac{1}{4}$  grain) is useful if there is much spasmodic dyspnea. For this symptom emetics are beneficial, given as in catarrhal spasm. The use of ipecac in smaller doses than is required for emesis (5 drops of the syrup of ipecac every



two hours) may give relief, especially in the early stage, when the cough is dry, hard and severe.

All the remedies mentioned are to be regarded as accessories to the essential treatment, which consists in the use of inhalations. The child should be placed in a tent into which steam is introduced from a croup kettle. Simple steam may be used, or pine-needle oil; compound tincture of benzoin, or creosote may be added. In moderately severe cases inhalations should be used for fifteen minutes every two hours; in very severe ones they should be continued the greater part of the time. Hot applications may be applied over the larynx. Relief is sometimes obtained by using counterirritation by mustard. In our experience the local use of cold is very unsatisfactory, on account of the difficulty of applying it properly and the objection to it on the part of young children.

In cases of extreme dyspnea operative interference may be needed. If pallor, marked prostration and steadily increasing dyspnea are present, intubation should be performed; the severity of the dyspnea is the only guide. Removal of mucus and other secretions from the larynx by suction carried out with a direct laryngoscope at frequent intervals may obviate the necessity of intubation. Even when intubation has proved necessary, the tube can generally be dispensed with in two or three days; convalescence is usually rapid, unless pneumonia develops.

The question often arises whether diphtheria antitoxin should be withheld until the results of a throat culture are obtained. As a rule one may do this, but if the case is clinically suspicious or if the laryngitis is severe antitoxin should not be delayed.

### SUBMUCOUS LARYNGITIS—EDEMA OF THE GLOTTIS

These two conditions are not quite identical, although they are closely associated and may be conveniently considered together. They are both rare in early life. In true edema of the glottis there is simply a dropsical effusion into the submucous cellular tissue of the aryteno-epiglottic folds, causing them to project as large rounded swellings on either side of the superior isthmus of the larynx. They may be of sufficient size to cause serious or even fatal obstruction to respiration. With the laryngoscope they appear as pale-red tumors, lying usually in contact near the base of the tongue. By the finger their presence can be quite readily distinguished. Edema of the glottis occurs principally in the late stages of nephritis; it may occur in acute anaphylactic shock, or as a rare manifestation of angioneurotic edema.

In the inflammatory form of edema, or true submucous laryngitis, there is the same sort of swelling of these structures, but in this case it is due to some active inflammation in the neighborhood. The swelling is partly from the edema and partly from cell infiltration. Usually all the parts surrounding the upper opening of the larynx are in a state of acute inflammation. The epiglottis may be swollen to the thickness of a finger and easily seen by depressing the tongue. The exciting cause may be the mechanical irritation of a foreign body, the inhalation of irritating gases, any form of acute laryngitis, erysipelas of the neck, or retropharyngeal abscess. The removal of a laryngeal tube may be followed by edema.

The symptoms consist of suddenly developing dyspnea and cyanosis with



laryngeal stridor, most marked during inspiration. In the inflammatory form there are the evidences of local inflammation—hoarseness, cough, pain, difficulty in swallowing, and constitutional symptoms. A positive diagnosis may be made by inspection, with a laryngoscope if necessary. In edema the swollen folds may be felt by digital examination. The symptoms may develop with great rapidity in either variety, and frequently prove fatal in a few hours.

Scarification of the larynx is no longer used in treating this condition. In the inflammatory forms local application of ice externally or swallowing ice may bring relief; the child should be placed in a steam tent. Sprays of epinephrine (1:5000) or ephedrine (2 per cent) may be effective. Severe and increasing dyspnea requires tracheotomy; intubation is difficult to perform in the presence of edema and there is increased possibility of trauma.

### LARYNGEAL ABSCESS

This is a rather uncommon condition in children. It may occur, however, even in young infants. Descottes, reviewing the literature prior to 1912, was able to collect 30 cases; McIntosh and Nichol recently reported 5 cases which were observed personally. The abscess may complicate inflammations of the larynx, notably diphtheria, or foreign bodies in the larynx, but often there is no preceding laryngeal disease. In some instances laryngeal abscess has followed pharyngeal infections or erysipelas of the face and neck; it may be associated with general furunculosis. The bacteriology is variable, but streptococci seem to play the most important part. The abscess usually forms in the areolar tissue lying anterior to the epiglottis, between it and the thyrohyoid membrane. The pus may spread beneath the fascia surrounding the larynx but is not subperichondrial; in some cases edema of the larynx is present.

The symptoms are those of progressive laryngeal obstruction—dyspnea and stridor which is largely inspiratory; there may be aphonia and retraction of the neck. In most instances a mass can be palpated; it may be very prominent. It is usually felt anteriorly in the midline above the thyroid cartilage and moves with the larynx. In some instances bimanual palpation with one finger in the esophagus has been of assistance in locating a mass. In one of the recently reported cases the abscess was discovered accidentally while doing a tracheotomy. There may be enlargement of the submental lymph nodes. Laryngoscopy may reveal a normal larynx, or perhaps slight edema; in other cases there are the evidences of the complicating laryngeal disease; it is of little assistance in diagnosis. The finding of a mass is the most characteristic sign. The diagnosis may be confirmed by aspiration and the abscess opened by blunt dissection. Relief from the symptoms is often instantaneous, and recovery may be most dramatic.

### CHRONIC LARYNGITIS

A catarrhal inflammation of the larynx may persist for many months in the presence of chronic infection in the nose or paranasal sinuses. Adenoids are probably the most common cause. Removal of the focus of infection is usually followed by prompt disappearance of the laryngeal symptoms. Other causes of chronic laryngitis are tuberculosis, syphilis, neoplasms and foreign bodies.



*Tuberculous laryngitis* is rare in young children; it is usually associated with advanced pulmonary disease, and often with tracheitis. The symptoms are in no way characteristic, but ragged ulcerations can be seen with the laryngoscope; the ulcerations are superficial as contrasted with those found in adults. Tubercle bacilli are present in the sputum.

*Syphilitic laryngitis* is common in early congenital syphilis. There is nothing characteristic about the laryngitis clinically except its protracted course. The inflammation is a catarrhal one. Gummata of the larynx are exceedingly rare and found only as late manifestations.

Neoplasms and foreign bodies are considered below.

### NEW GROWTHS

The only neoplasm likely to be encountered in children is papilloma. This usually begins in early childhood and may occur even in infancy. It is more common in boys. The tumors are infectious and are apparently caused by the same virus which gives rise to the common wart. Like the latter, they have a marked tendency to spontaneous regression at the time of puberty.

The symptoms depend upon the size and location of the tumors. The earlier manifestations are usually ascribed to chronic laryngitis. There is hoarseness, sometimes loss of voice, and a paroxysmal cough; later, dyspnea develops which often increases by paroxysms. The symptoms are slowly progressive, and it may be several months before they are sufficiently severe to attract special attention. A positive diagnosis is made only by the laryngoscope. There is seen a whitish granular tumor or tumors, sometimes pedunculated, sometimes with a broad base, which may be attached to any part of the larynx. The prognosis is usually serious on account of the danger of postoperative pneumonia.

Removal of these tumors is almost invariably followed by recurrence. If dyspnea is relieved by tracheotomy one can often ignore them entirely, but the tube may be required for years. If the growths spread to the trachea, there is no alternative but repeated removal; this should be done superficially to avoid permanent injury to the voice. The outlook improves as puberty approaches.

### FOREIGN BODIES IN THE LARYNX AND BRONCHI

The aspiration of foreign bodies is not an uncommon accident in children. It results from a forcible inspiration when the child has something in his mouth; usually from an attempt to cough, sneeze, laugh or cry, sometimes from a fall or any unusual excitement which causes the child to take a deep breath. Choking and crying following the obstruction may cause further aspiration. The variety of objects that may be aspirated is enormous; the collection of Chevalier Jackson includes all kinds of hardware, jewelry, pins and needles, safety pins, seeds, nuts and shells, bones, food, buttons, dental appliances and a great variety of toys. Ascaris worms have been known to crawl down the larynx during sleep. Whether the object becomes impacted in the larynx or passes downward into the trachea and bronchi depends upon its size and shape. Larger bodies and those with sharp irregular edges like pins, shells, bones and nuts are likely to become impacted



higher up; smooth and small objects like peas and beads are usually drawn into one of the bronchi, generally the right.

When the body enters the larynx there is immediately excited a violent paroxysm of coughing, with dyspnea amounting almost to suffocation. This initial attack of coughing may dislodge the object. If the object remains impacted it may cause sudden death by occluding the glottis. If the obstruction is not complete the paroxysm of coughing subsides after a time, although it may recur. An acute laryngitis develops, often of considerable severity. In a child too young to give a history, if the aspiration has not been observed, the mistake is often made of regarding the condition as diphtheria or some form of infectious laryngitis. The symptoms do not tend to clear up, however, and expectoration is sometimes blood-streaked. There may be peculiar whistling sounds heard, or flapping sounds if the body is movable. If the body is allowed to remain a longer time, it may cause suppuration and even perforation of the larynx; it may cause an esophageal fistula. The possibility of its being coughed up or being dislodged and passing downward decreases the longer it remains in place. The degree of reaction about an impacted foreign body will depend in part upon its nature; nuts seem to be particularly irritating substances and are likely to induce suppuration rapidly; metallic substances are less irritating, and if they lead to abscess formation this usually requires two or three weeks or more. Granulations may surround a foreign body that has been present a long time.

A foreign body that passes the larynx sometimes becomes impacted in the trachea; usually it is arrested at the bifurcation or in the primary bronchi. There may be attacks of paroxysmal coughing and pain in the chest; in some instances there is bloody expectoration. Fatal obstruction in the trachea and bronchi is rare. The symptoms of obstruction are symmetrical if the foreign body lodges in the trachea, but if it penetrates to a primary bronchus, the signs of unilateral obstruction are found.

With *complete obstruction of a primary bronchus* there is at first emphysema, but this is followed by collapse of the lung. There is limitation of motion on the affected side of the thorax; dulness follows the early hyperresonance; the breath sounds are distant or absent. If the obstruction involves a secondary rather than a primary bronchus the signs may be confusing; compensatory emphysema in the surrounding unobstructed lung may cause tympany. There is usually dyspnea and often cyanosis.

With *partial obstruction* the affected part of the lung does not collapse but remains emphysematous. The breath sounds and voice are feeble; localized wheezing or crepitant râles are usually heard. A whistling sound may be detected with the stethoscope placed over the child's mouth.

Foreign bodies which remain impacted in the bronchi excite a variable amount of local inflammation which may terminate in the formation of an abscess. Peanut shells, according to Jackson, are particularly irritating, but abscess formation may occur with any foreign body. The result is a prolonged illness with hectic symptoms, often mistaken for pulmonary tuberculosis; if untreated the condition may terminate fatally. In rare instances, the foreign body is coughed up after weeks or months. In other instances no abscess develops but there are repeated attacks



of acute pneumonia which never resolve entirely; chronic pneumonia and bronchiectasis develop; the general health is greatly interfered with and the patient is likely to succumb to one of the acute attacks, or to some intercurrent disease.

The diagnosis of a foreign body in the respiratory passages is easy enough if there is a history, or if the original attack of coughing has been witnessed; without these aids it may be very difficult. Any obscure laryngitis which does not clear up is an indication for laryngoscopic examination. Cases of localized bronchitis and of chronic pneumonia with developing bronchiectasis must always be looked upon with the possibility of foreign body in mind. The same applies to any case presenting the signs of bronchial occlusion. The x-ray often indicates the presence of opaque foreign bodies; plates taken in several planes may make an exact localization possible. Stereograms are difficult to obtain in young children, since a certain amount of coöperation is required.

**Treatment.**—For the immediate relief of laryngeal obstruction tracheotomy may be necessary. The removal of foreign bodies should be left to the specialist in bronchoscopy. The traditional remedy of inverting the child and making him cough is of little value; instances in which this maneuver has resulted in the expulsion of the foreign body are very rare; this procedure may cause an object in a bronchus to pass into an ascending branch where it becomes inaccessible to the bronchoscope. The results of bronchoscopy are usually satisfactory in the hands of a skilled operator. A general anesthetic is not necessary and even local anesthesia can usually be dispensed with; this diminishes the risks of post-operative pneumonia. In cases of long standing complete recovery cannot be regularly expected, for much permanent damage may have occurred. Even in such instances one is often astonished at the completeness of recovery once the foreign body has been removed.

Much can be done to prevent such accidents by intelligent watchfulness and choice of a child's toys. Toys which are small and which have detachable parts should be avoided; nuts should not be included in the diet of young children. In many instances, damage is done by unwise attempts to remove foreign bodies in the pharynx; the object may be dislodged only to pass into the larynx.

The aspiration of nonabsorbable liquids gives rise to a clinical and pathological picture quite distinct from that just described. This is discussed elsewhere (see Lipoid-cell Pneumonia).

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# SECTION VII

## DISEASES OF THE LUNGS

### CHAPTER XLII

#### PECULIARITIES OF THE THORAX IN CHILDREN

The general shape of the thorax is somewhat cylindrical, the conical or dome-shape of the adult thorax not being attained until puberty. The anteroposterior and the transverse diameters are nearly equal in the newly born, but after the third year the transverse diameter is always greater, the difference increasing steadily up to adult life.

The thoracic walls are very elastic and yielding, since a greater part of them consists of cartilage. They are relatively thinner than in the adult. Hence obstructive dyspnea produces far greater deformities than in older subjects.

Microscopically the lungs show marked differences. The trachea and bronchi occupy a greater space and are relatively larger. The alveoli are smaller and the interstitial tissue is more abundant. There is hence a greater tendency to acquired atelectasis. Acute congestion may cause almost as complete obstruction of the alveoli as true consolidation.

**Respiration.**—The rapidity of respiration during sleep at the different ages is as follows:

<i>Age</i>	<i>Respirations per Minute</i>
At birth .....	35
At the end of the first year.....	27
At two years .....	25
At six years .....	22
At twelve years .....	20

During waking hours this rate is very materially increased, and from a comparatively slight disturbance it may be nearly twice as rapid. In all forms of pulmonary diseases respiration is always more rapid than in adults.

The type of respiration in infants is diaphragmatic, and it continues to be chiefly so until after the seventh year, when the costal element gradually becomes more and more prominent. The rhythm of respiration is easily disturbed. In very young infants the regular rhythm is seen only in sleep. The lungs do not always expand equally; at certain times and in certain positions respiration may be carried on for a few moments almost entirely with one lung. For some moments it may be very superficial, and then quite deep. The length of the interval between inspiration and expiration varies much at different times. Regular rhythmical respiration



is not fully established before the end of the second year. After this time disturbances of rhythm are due chiefly to pulmonary or cerebral disease; but in infancy quite marked irregularity may have little or no significance. In disease of the nervous system irregularity and periods of apnea are often seen, but there is more likely to be an "irregular irregularity" than the regular crescendo and diminuendo followed by apnea seen in true Cheyne-Stokes breathing.

Infants suffering from acidosis often exhibit the typical Kussmaul "air hunger" respiration—a slow, very deep breathing in which the accessory muscles take part.

**Physical Examination.**—This requires tact and time, but yields results which are quite as satisfactory as in adults.

*Inspection.*—There should be noted: deformities from rickets, the want of symmetry in the two sides, bulging of the intercostal spaces, variations in rhythm, and recession of the soft parts or bony walls as an indication of obstructive dyspnea.

*Palpation.*—This also should be made upon the bare skin, always with the hand warmed. The vocal fremitus of cry or voice is usually more intense than in adults, on account of the thin chest walls.

*Percussion.*—For the examination of the back, the infant is best laid face downward upon the nurse's lap, or seated upon her arm. The normal percussion note has a quality somewhat tympanitic, this being due to the relatively large bronchi and the thin chest walls. This is exaggerated in the interscapular region and beneath the clavicle, especially upon the right side. Here cracked-pot resonance may be obtained even in health. Should an abnormality of the percussion note be heard, the child should be placed in another position in order to be sure that the alteration is persistent.

*Auscultation.*—The normal respiratory murmur of the infant is often described as "puerile." It is rude, rather loud, and seems very near the ear. Its peculiar character is due to the fact that the tracheal and bronchial sounds are more distinct, because not transmitted through so thick a layer of lung and chest wall. It is especially loud in the regions where the bronchi are superficial, as between the shoulder blades and beneath the clavicles, particularly of the right side. The infant's position should be changed several times during auscultation, to avoid the mistake of attaching too much importance to a feeble respiratory murmur of one side.

Before drawing any inference from the auscultatory signs, both lungs must be examined for several minutes, changing the child's position, and often inducing a cry or compelling a deep inspiration by other means, in order to bring out signs which otherwise may be overlooked. The voice is of more value than quiet breathing in the examination of infants.



## CHAPTER XLIII

### INFLAMMATION OF THE TRACHEA AND BRONCHI

#### TRACHEITIS

This occurs most frequently as a complication of a common cold. It is also seen in many other specific infectious diseases associated with pharyngitis, laryngitis or bronchitis. The specific symptoms are soreness or a tickling sensation more or less well localized in the neighborhood of the suprasternal notch. There is a cough which may be loose, dry or paroxysmal. There are no physical signs in the chest in uncomplicated cases. The treatment is the same as that of bronchitis.

#### ACUTE BRONCHITIS

Bronchitis may be primary or secondary. Infections that may be regarded as primary result from a downward extension of a common cold. The predisposing factors have been discussed in connection with that disease. Even in such instances, however, it is likely that the bronchitis is not caused directly by the cold virus, but that secondary invaders are chiefly if not entirely responsible for it. In rare cases bronchitis is caused by the inhalation of irritants. Bronchitis is an almost invariable accompaniment of measles and pertussis. It is very common in influenza, in scarlet and typhoid fevers, and diphtheria, and may occur in any acute infectious disease. The micro-organisms associated with bronchitis are the ordinary pyogenic bacteria: pneumococci, streptococci, staphylococci and influenza bacilli.

**Pathology.**—Ordinarily, bronchitis is a diffuse process, a localized bronchitis existing only in connection with pulmonary disease of some kind. In older children, as in adults, the inflammation seldom extends beyond the larger tubes, but in infants a severe form is seen in which the smallest tubes are involved (capillary bronchitis), a condition which is often associated with disseminated bronchopneumonia.

The pathological changes consist in a catarrhal inflammation confined to the mucous membrane. In some cases the exudation of fibrin is a prominent feature (croupous bronchitis). When this form extends to the smaller tubes the disease becomes a serious one. Peribronchial changes are likely to be found in these cases.

Emphysema is often found complicating the bronchitis of young infants. This usually subsides rapidly after the acute attack is over. Swelling of the lymph nodes at the root of the lungs in most acute cases is slight, but in protracted cases, and after recurring attacks, may be quite marked.

**Symptoms.**—Bronchitis in older children resembles very closely the condition as it is seen in adults. The onset is generally gradual, and usually follows pharyngitis or laryngitis. The extension of the process to the bronchi is accompanied by an alteration in the character of the cough and perhaps by a slight acceleration



of breathing. The temperature rarely exceeds 102° F. and usually lasts but a day or two; there may be no fever at all. In most instances few constitutional symptoms are present, although in certain epidemics such symptoms may be marked. During the early part of the infection the cough is likely to be dry and unproductive; later on there is an abundant secretion which is first mucous and then mucopurulent. The chest is then full of râles of all kinds; rhonchal fremitus is readily felt. It usually requires ten to fourteen days before the secretions have returned to normal, although fever and constitutional symptoms rarely last more than two or three days. Relapses may occur, and occasionally they are so frequent as to warrant regarding the disease as a chronic bronchitis.

In infants, bronchitis presents several peculiarities. Fever and constitutional symptoms are usually more marked; the temperature is often between 102° and 104° F.; there is fretfulness and loss of appetite. There may be diarrhea and vomiting. The degree of respiratory embarrassment is greater. Although cough is equally prominent the secretions are not coughed up, but are either swallowed or aspirated.

Attacks of bronchitis in young infants are frequently accompanied by marked spasm of the smaller tubes (spasmodic bronchitis). The degree of respiratory distress in these cases is very marked; the accessory muscles of respiration are used and there is recession of the soft parts of the chest wall. The respirations may be 50 to 80 a minute, and there may be cyanosis. On auscultation, fine sibilant râles are heard everywhere; expiration may be prolonged. The percussion note may be hyperresonant from emphysema.

With the exception of capillary bronchitis, which is discussed elsewhere, and the rare membranous form, bronchitis is not a serious disease even in infants. The mortality is confined to children who are in poor physical condition to start with, and those suffering from other diseases.

**Treatment.**—Rest in bed should be enforced as long as fever is present. Many of these patients do badly with cold air, their cough may be aggravated; for such, a warm room is preferable. Sunlight is always desirable. For a hard, dry cough inhalations of steam alone or with the addition of benzoin, creosote or eucalyptol may be employed. These may be used for ten or fifteen minutes four to eight times a day. A croup kettle and tent may be used for infants; older children can use inhalers.

In infancy expectorants may advantageously be dispensed with. For older children ipecac may be used; small, frequently repeated doses usually give the best results. Potassium iodide or ammonium chloride are quite as satisfactory. Brown mixture (mist. glycerrhizae comp. U.S.P.) combines expectorant and sedative properties. It is usually advisable to have the formula made up with half the customary amount of opium. Mild sedatives are all that are usually required in bronchitis; codeine or luminal (phenobarbital) are quite satisfactory. When there is much dyspnea of the asthmatic type, epinephrine or ephedrine will bring marked relief. Aspirin is useful for headache, pains and general discomfort in older children.

When attacks of bronchitis are frequent and prolonged a change of climate is sometimes the only effective remedy. It is a belief held for some years that cod



liver oil enhances the resistance to infections—particularly of the respiratory tract. This rests on clinical impression rather than scientific evidence.

### MEMBRANOUS BRONCHITIS

In diphtheria, severe cases are sometimes seen in which fibrinous membrane extends down from the larynx and trachea, and may reach even the smallest tubes. The membrane may be loose or adherent. A similar condition is occasionally produced by pyogenic organisms, most frequently hemolytic streptococci.

The clinical picture is characterized by severe dyspnea and the expectoration of tube casts from the larger bronchi, or elongated cylinders from the smaller ones; the former resembling macaroni; the latter, vermicelli. The expectorated masses are often in balls or plugs, and their peculiar character is not recognized until they are placed in water. The casts are dissolved by alkalis. After the expulsion of a large cast, improvement in all the symptoms occurs but these may return as the exudate reappears. These cases are associated with a high mortality. Often they are complicated by pneumonia. Recovery may occur, however, the condition gradually subsiding after two or three weeks, during which time numerous casts may have been expelled.

Treatment is quite unsatisfactory. To loosen the membrane and facilitate its expulsion, the most efficient means are inhalations of steam. Occasionally emetics and expectorants are of value. Oxygen is often indicated.

### CHRONIC BRONCHITIS

Chronic bronchitis is not very common in young children. It usually follows acute attacks which have recurred at frequent intervals. Chronic bronchitis may accompany chronic asthma or chronic passive congestion of the lungs. It occurs as part of the picture of a chronic interstitial pneumonia. As in adults, it is usually associated with emphysema.

**Symptoms.**—The only constant symptom is cough, which is persistent, obstinate, and nearly always worse at night or early in the morning. It often occurs in paroxysms strongly suggestive of pertussis. Expectoration is seldom profuse. A copious morning expectoration of fetid pus or mucopus should suggest bronchiectasis. There is no fever, little or no dyspnea, and in many cases the general health is not much affected. There may be coarse mucous râles, or no physical signs whatever. The duration of the disease is indefinite. All these patients are better in summer than in winter, and suffer frequently from exacerbations of acute or subacute bronchitis.

The condition is to be distinguished from pertussis, tuberculosis and chronic nontuberculous pneumonia. An x-ray may be necessary to exclude a pulmonary lesion. In any case of chronic cough the heart deserves a careful examination.

**Treatment.**—The first indication is to discover and treat any primary condition upon which chronic bronchitis may depend. Expectorants, inhalations or sedatives may be needed at times. Sunlight seems to be of definite benefit, more so than artificial actinotherapy. In resistant cases a change of climate is often of great value.



## CHAPTER XLIV

### MALFORMATIONS OF THE LUNGS

These are very rare. Two general types are met with. There may be *agenesis of one lung*. In such instances the healthy lung hypertrophies and fills both sides of the chest. Often there is marked displacement of the heart as in the case illustrated in Figure 49. Dextrocardia occurs when the right lung is absent. Many of these cases are compatible with long life; except for displacement of the heart there may be no symptoms or physical signs.

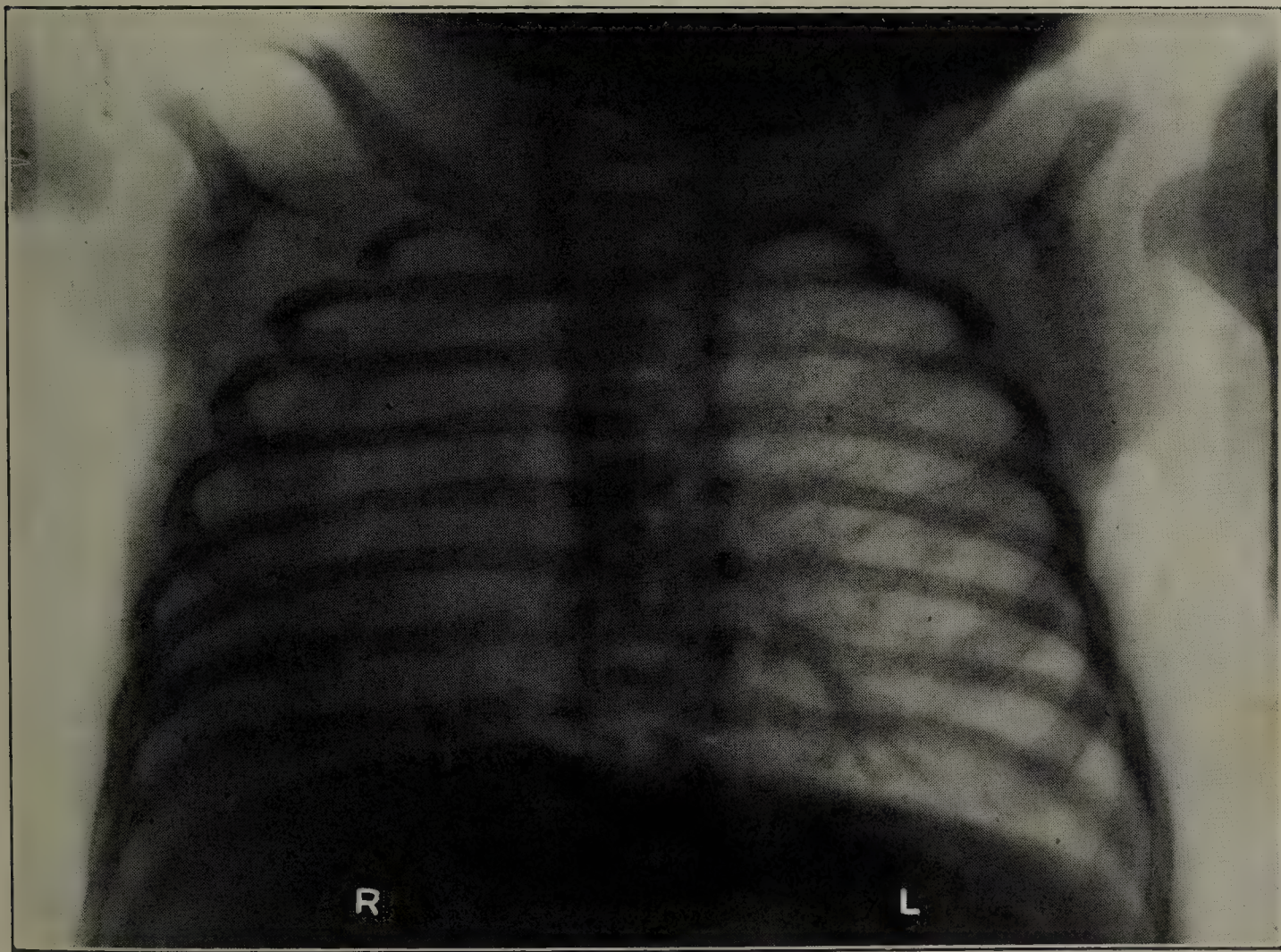


FIG. 49.—AGENESIS OF RIGHT LUNG; DEXTROCARDIA.

*Congenital cysts of the lung* are occasionally encountered. In some instances they communicate with the bronchi (congenital bronchiectasis); in other instances there is no such communication. The cysts may be single or multiple; sometimes they occupy the greater part of a lobe. In the neighborhood of these cysts areas of atelectasis are often found. If the changes in the lungs are extensive, symptoms of asphyxia are present, and such infants do not survive more than a few weeks at most. When the process is not extensive there may be no symptoms for a time. These patients are, however, unusually susceptible to respiratory infections, and most of them succumb during childhood.



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# CHAPTER XLV

## LOBAR PNEUMONIA

**Etiology.**—Lobar pneumonia (primary localized pneumonia) may occur at any age. We have seen it in an infant of three months; but it is not until after the first year that it begins to be frequent. After the third year most of the cases of primary pneumonia are of this variety. Attacks may occur at any season but are most frequent during the first four months of the year; the peak of these infections usually occurs in March.

Although lobar pneumonia occasionally follows some other infectious disease, the great majority of these infections are primary and occur in children previously healthy and robust. There can be little question that the infection is acquired by contact; however, the disease does not spread in epidemic form. It is unusual for more than one member of a family to be attacked. There is no reason to believe that one attack of lobar pneumonia predisposes to another. Second attacks are occasionally seen; they may follow closely upon the first attack or may occur years later. But quite as often as not the second attack involves a different portion of the lungs.

The bacteriology of these primary pneumonias appears to differ little from that of lobar pneumonia in the adult. The great majority of cases are due to one or another type of pneumococcus, although other pyogenic organisms are occasionally responsible. Some observers have reported that nearly all primary pneu-

TABLE XXXII  
MORTALITY PERCENTAGES FROM DIFFERENT TYPES OF PNEUMOCOCCUS ISOLATED FROM PRIMARY PNEUMONIAS IN CHILDREN AT NEW HAVEN

	Pneumococcus Type					Non-pneumo- coccal	No Etio- logical Diag- nosis	Total Cases
	I	II	II Atypical	III	IV			
Cases .....	36	5	3	10	30	1	11	96
Deaths .....	2		1		3			6
Mortality percent- age .....	5.5		3.3		10			6

monias are due to Type IV pneumococci. It seems quite likely that these results are to be explained by the fact that the sputum obtained for culture was often obtained from the pharynx rather than the lungs. When lung punctures are done, the overwhelming predominance of the Type IV pneumococcus is not seen. The accompanying table gives the organisms isolated from primary pneumonias in children at New Haven by Trask and his associates.



**Pathology.**—In general the anatomical changes resemble those in the adult lung. The stages of congestion, red hepatization, gray hepatization and resolution are seen, and in individual alveoli the picture is identical with the lobar pneumonia of later life. The stage of congestion which lasts from a few hours to several days shows under the microscope an engorgement of the blood vessels and beginning exudation into the alveoli, the exudate consisting of serum with red cells and

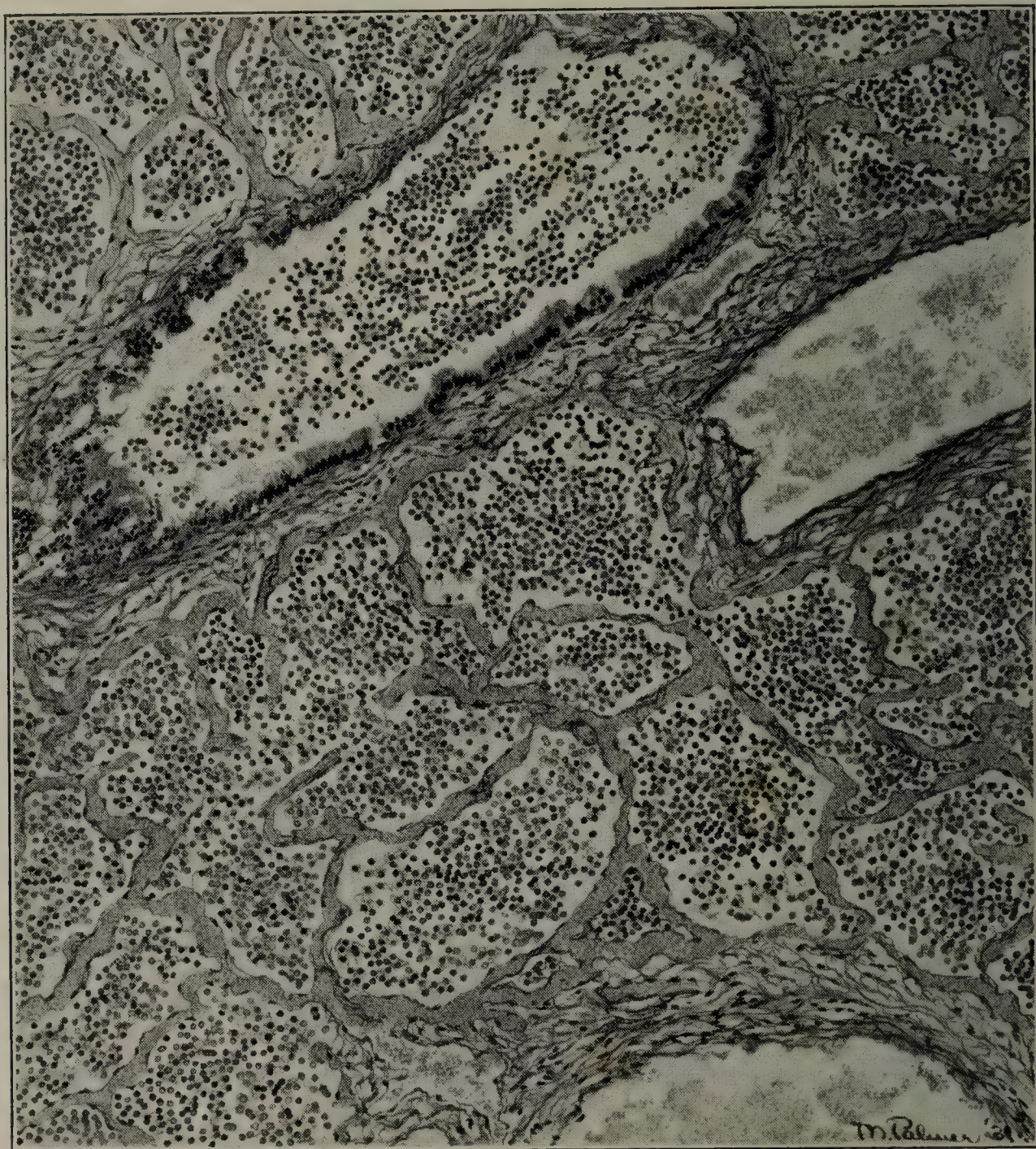


FIG. 50.—LOBAR PNEUMONIA: MICROSCOPIC APPEARANCE.

leukocytes; organisms are present in large numbers. In the gross such areas are edematous, heavy and dark red in color.

In the stage of red hepatization the gross appearance of the tissue is dark red; it is firm in consistency and cuts like liver; the cut surface is dry and granular. Microscopically the alveoli are found distended with an exudate containing fibrin, red cells and leukocytes. Organisms are still abundant. The smaller bronchi are filled with exudate; the larger ones may show inflammatory changes, but the interstitial tissue of the lung is unaffected. This stage lasts several days (Fig. 50).

Eventually the inflammatory products disintegrate, especially the red cells, the consolidation becomes partly decolorized (stage of gray hepatization). After



a longer or shorter time there is complete degeneration and liquefaction of the inflammatory products, which are carried away largely by the lymphatics, being removed by coughing only to a negligible extent.

In older children, the pathology of these pneumonias is often identical with that seen in adults. The process is uniform throughout the consolidated area, so that one can say definitely that the lung is in the stage of congestion or red or gray hepatization, as the case may be. The border between the consolidated area and the adjacent lung is usually sharp, and as a rule the process is limited by the boundaries of a lobe.

In contrast to this, in the localized consolidations of young children the changes are rarely uniform. Congestion and red and gray hepatization are seen simultaneously in different parts of the consolidated area. The border of the consolidation is rarely uniform; patches of consolidation are seen interspersed among normal alveoli. Primary localized pneumonia in early life is more properly designated "confluent lobular pneumonia" rather than lobar pneumonia.

Although the disease may involve one or more lobes, which serve as boundaries for the consolidation, more frequently only a circumscribed part of a lobe is involved. In order of frequency the process affects the left base, the right apex, the right base and, lastly, the left apex.

In some cases fibrinous pleurisy may be a very prominent feature. Such cases are considered separately (pleuropneumonia).

*Lesions in Other Organs.*—There is regularly an acute inflammation of the bronchial lymph nodes in the vicinity of the lesion; often all the nodes are the seat of such a process. Other lesions are due to the localization of the pneumococcus, or whatever the etiological agent may be, in other tissues. Otitis media, meningitis, parotitis, arthritis, endocarditis or peritonitis may be found. Pericarditis occurs in rare instances, even in young infants; it usually represents a direct extension of pleural inflammation. Metastatic lesions occur when there has been extensive infection of the blood stream.

*Chemical Changes.*—As in any form of pulmonary disease there is an increased oxygen unsaturation of the arterial blood, in direct proportion to the severity and extent of the lesion. It might be expected that inadequate pulmonary ventilation would produce an acidosis, but it is surprising how infrequently this occurs. Many observers have noted a retention of chloride and total base during the initial phase of the disease; the total base of the plasma is diminished. With resolution these changes disappear; there is a marked excretion of the retained electrolytes in the urine. If one may judge by carbohydrate tolerance tests, liver function is frequently impaired during an acute pneumonia. This does not, however, imply that an anatomical lesion is present. Ketonuria is common during these infections.

*Symptoms.*—In many respects lobar pneumonia in young subjects tends to differ from the picture as presented by older children or adults. The onset is rarely with a chill; as a rule there is vomiting and perhaps one or more convulsions. Vomiting and diarrhea may persist throughout the attack or even longer, but in most cases gastro-intestinal symptoms are confined to the onset. Sputum is not in evidence, for young subjects tend to swallow it. The disease is much more



variable in its duration, in the type of fever and in the degree of prostration. The blood picture may show unusual reactions. The mortality is distinctly less.

In a typical case, a child three or four years of age, after a few hours of slight indisposition, suddenly begins to vomit and this is followed by a rapid rise in temperature. He is dull and apathetic, complains of headache and general weakness, refuses food, and is easily persuaded to remain in bed. He has the appearance of being quite ill, even after a few hours. Occasionally sharp pain in the side is complained of. The skin is dry; there is marked thirst, restlessness, and the other symptoms which accompany fever. The temperature is found to be 104° F., or even higher; the respirations 40 to 50 a minute; the pulse full, strong, and 120 to 130. On the second day the patient is no better. The temperature remains high; cough is present and may be quite frequent.

After the second or third day the patient is usually more comfortable, and sleeps better, but may be disturbed by the cough. At times there is restlessness, and at night there may be slight delirium. The respiration continues rapid and the temperature high. There is little change until the sixth or seventh day, when, after a long sleep, the patient wakes, decidedly improved as to all his symptoms. There is less fever, and the temperature continues to fall rapidly until it touches the normal line, or it may even go below this. As the fever subsides the pulse drops to 90 or 100, and the respirations to 25 or 30 a minute. The appetite soon returns, and convalescence is rapid.

*Onset.*—This is usually abrupt, prodromal constitutional symptoms seldom lasting more than a few hours. In some cases the attack develops in the course of what appears to be a common cold; a sudden exacerbation in the fever, and increasing cough and rapid respiration mark its development.

*Cough.*—This may not be marked for the first day or two; it is seldom a distressing symptom. Children under five years almost invariably swallow their sputum; older children may bring up at first a white, viscid or brownish-red sputum loaded with organisms; later this becomes purulent.

*Pain.*—It is difficult to detect pleural pain in a young child; hence this symptom is of little value. When there is diaphragmatic pleurisy and abdominal pain, pneumonia can readily be confused with acute surgical conditions, as in adults, and this may lead to an unnecessary laparotomy.

*Respiration.*—This is always accelerated, and generally out of proportion to the pulse. The normal ratio of respiration to pulse is one to four; in pneumonia it is frequently one to two. The rapidity is usually in proportion to the amount of lung involved but there are striking exceptions. The most characteristic type of respiration is a short inspiration, then a momentary pause, followed by a quick expiration which is accompanied by a grunt.

*Pulse.*—In the early part of the disease this is full and strong, usually varying from 120 to 150 per minute. Later it may become weak, compressible and somewhat irregular. The character of the pulse is of more importance than the rate.

*Gastro-intestinal Symptoms.*—As has been mentioned, these occur chiefly at the onset. A continuation of vomiting or diarrhea may be due to failure to restrict the food, or to improper medication. Tympanites is often a distressing symptom, and may affect the prognosis unfavorably.



*Prostration.*—The amount of prostration is highly variable. Few patients escape it entirely, but it is often surprising to see young children with consolidation involving the greater part of one lung who do not seem particularly ill, and who may sit up in bed and play with toys. In sharp contrast with these are a small proportion of patients who exhibit extreme prostration; the onset is usually with convulsions; often there is sustained hyperpyrexia. There may be no cough or pulmonary symptoms, the toxemia dominating the picture, and the pneumonia being discovered only postmortem. The breathing may be slow and of the air-hunger type; in such instances an acidosis can often be demonstrated.

*Cerebral Pneumonia.*—This term has been applied to cases in which nervous symptoms predominate. The onset is with convulsions and the child passes rapidly into delirium or perhaps coma. Meningeal symptoms may be conspicuous; opisthotonos, irregular pupils, irregular respiration, rigidity of the neck, retracted abdomen, a positive Kernig sign and marked tache. Without a lumbar puncture it is often impossible to exclude meningitis. These symptoms may persist for several days. When the spinal fluid is examined it is found to be under high tension, but as a rule there are no organisms and either a slight increase in cells and globulin or none at all. Sometimes the cerebral symptoms continue up to the time of crisis.

*Course.*—Abortive types of pneumonia are seen in which the symptoms may be severe for a day or two, following which prompt resolution occurs. The temperature curve in such a case is shown in Figure 53. In other instances the infection may be unduly prolonged. The pneumonia may last as long as three or four weeks and then resolve completely. In some instances a prolonged course is due to involvement of a new lung area (*wandering pneumonia*). A prolonged temperature with physical signs localized in one area should always suggest complications, usually empyema. The accompanying table gives the day of crisis in 567 cases:

TABLE XXXIII  
THE DAY OF CRISIS IN 567 CASES OF PNEUMONIA

Day	Cases	Day	Cases
Second .....	3	Eleventh .....	18
Third .....	22	Twelfth .....	7
Fourth .....	43	Thirteenth .....	8
Fifth .....	88	Fourteenth .....	7
Sixth .....	83	Fifteenth .....	1
Seventh .....	132	Eighteenth .....	3
Eighth .....	73	Twenty-first .....	1
Ninth .....	55	Twenty-sixth .....	1
Tenth .....	22		

*Temperature.*—The typical temperature curve of lobar pneumonia (Fig. 51) is characterized by an abrupt rise, usually to 104° or 105° F., and by daily fluctuations, generally within the limits of two or three degrees until the crisis, at which time the temperature falls to normal, usually in the course of twenty-four hours. After this time it does not go above the normal line. Such a curve is seen with the majority of patients over three years of age



In young children it is not uncommon for the temperature to be of a more or less remittent type. These wide fluctuations often lead to difficulty in diagnosis, particularly if the physical signs appear late, as they not infrequently do.

The chart shown in Figure 52 illustrates three features which are often seen in pneumonia: (1) A temperature which early in the disease is steadily high and as the day of crisis approaches becomes remittent; (2) a secondary rise after being subnormal for twenty-four hours, which was due in this instance to an extension of the disease to a new part of the lung; (3) a fall to a point considerably below normal at the time of the crisis. A fall to 96.5° to 97° F. at the time of crisis is not uncommon.

In the foregoing cases the fever terminated by crisis. In Figure 53 is shown one ending by lysis. This is a mode of termination much more frequent in young children than in those who are older. The causes of a postcritical rise in the temperature are chiefly two—extension of the disease to a new area, or the development of empyema. Less frequently it is due to otitis, meningitis, pericarditis or peritonitis. In fatal cases the temperature is generally high

until the end. In general, it may be said that the temperature is considerably higher in children than in adults; in the majority of cases it reaches 105° F., the usual range being from 102° to 105° F. In 15 of 137 cases it reached 106° F. or over.

*Skin.*—The face, in pneumonia, is usually flushed, sometimes on both sides and sometimes only on one; in other cases it is pale, but not indicative of pain. Cyanosis is rare except toward the close of the disease and is usually a sign of respiratory failure. Herpes of the lips or face is quite frequent in children over two years of age.

*Urine.*—Throughout the febrile period of the disease the urine is scanty, high-colored, with a high specific gravity, usually loaded with urates and with marked diminution of the chlorides. A moderate acetone reaction is very common. In a small proportion of cases a trace of albumin may be found, and occasionally a few hyaline casts. Evidences of serious renal disease are seldom found in lobar pneumonia in early life. Type-specific precipitins are found in the urine in many of the more severe cases.

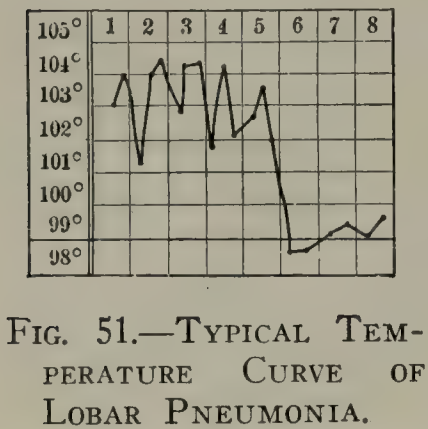


FIG. 51.—TYPICAL TEMPERATURE CURVE OF LOBAR PNEUMONIA.

Male, three years old; in fair condition; sudden onset; signs of consolidation—bronchial respiration and voice, and dullness—over left lower lobe behind, not distinct until the morning of the fifth day. On the seventh day lung was resolving.

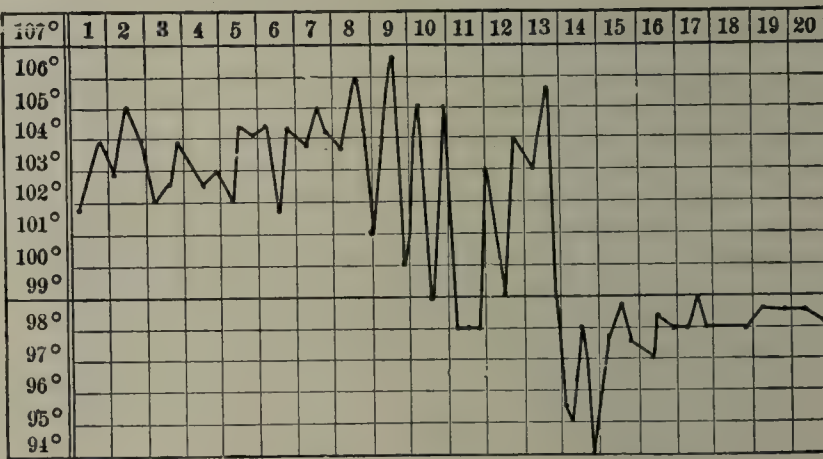


FIG. 52.—LOBAR PNEUMONIA WITH SUBNORMAL TEMPERATURE AFTER CRISIS.

Female, nineteen months old; fairly healthy, sudden onset; symptoms typical but physical signs delayed; consolidation in left mammary region on the eighth day; on the ninth in right lung middle lobe; on the eleventh day a pseudocritical drop followed after twenty-four hours of apyrexia by a further rise, which was accompanied by signs of extension of the disease in the right lung. Resolution rapid after crisis.



**Blood.**—A marked polymorphonuclear leukocytosis is a characteristic feature of lobar pneumonia; the exceptions are in very mild cases or very severe infections with little or no reaction. The increase begins shortly after the onset and continues during the stage of exudation, generally reaching its maximum shortly before the crisis, when it declines rapidly. The average number of white cells in a young child with pneumonia is from 25,000 to 40,000 but it is not rare for the count to be as high as 50,000 or even 60,000. We have seen it over 100,000 several times. In many of these cases there is an abundance of early myeloid forms. The absence of leukocytosis in a strong child who is acutely ill is always strong presumptive evidence against pneumonia. A well-marked leukocytosis is of much value in differentiating pneumonia from typhoid fever. Positive blood cultures were obtained in the Babies' Hospital in 14 per cent of 108 cases studied. Otten found almost exactly the same proportion in a study of 70 cases. These observations indicate that positive cultures are much less frequent than in the pneumonia of adults. The presence of a small number of colonies, three or four, in the culture does not appear to influence the prognosis. Cases with a large number almost always prove fatal. Shortly before death bacteriemia is often present.

**Physical Signs.**—The earliest signs in pneumonia are due to acute congestion of the affected lung or lobe, in consequence of which less air enters this portion and more air the rest of the lungs. Percussion reveals diminished resonance or slight dulness, often of a somewhat tympanitic character, over the affected area, and exaggerated resonance over the remainder of this lung and over the opposite lung. Auscultation over the affected lobe gives a feeble respiratory murmur, rather high in pitch; sometimes suppression of the breath sounds is so marked as to suggest fluid. The normal respiratory murmur over the healthy portions of the lungs is intensified. In children this exaggerated breathing is not infrequently mistaken for bronchial breathing, and the physician may be led into the error of locating the pneumonia upon the wrong side. If the chest is frequently auscultated, crepitant or fine subcrepitant râles may usually be heard at some period at the end of full inspiration; often they are present but for a few hours, and they may be missed altogether (Figs. 54, 55, 56).

A study of cases of lobar pneumonia by the x-ray shows that consolidation occurs quite early, usually first at the surface of the lung, gradually extending inward as the disease progresses (Fig. 57), bronchial breathing not being usually obtained until the consolidation has reached the hilum of the lung. Feeble breathing and slight dulness appear earlier.

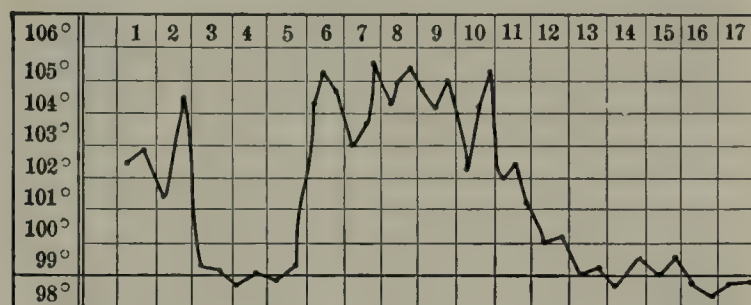


FIG. 53.—ABORTIVE PNEUMONIA IN LEFT LUNG, FOLLOWED BY TYPICAL PNEUMONIA IN RIGHT LUNG, TERMINATING BY LYSIS.

Male, seventeen months old, healthy; sudden onset, on the second day disseminated fine râles in both lungs behind, and over left lower lobe very feeble respiration, high-pitched—*i.e.*, some bronchitis, with congestion (?) of left base. On the third, fourth, and fifth days, general symptoms gone and signs nearly disappeared. On the sixth day, all symptoms of pneumonia present, and on the seventh distinct consolidation of right base, rest of chest clear. Subsequent course typical, resolution rapid and complete.



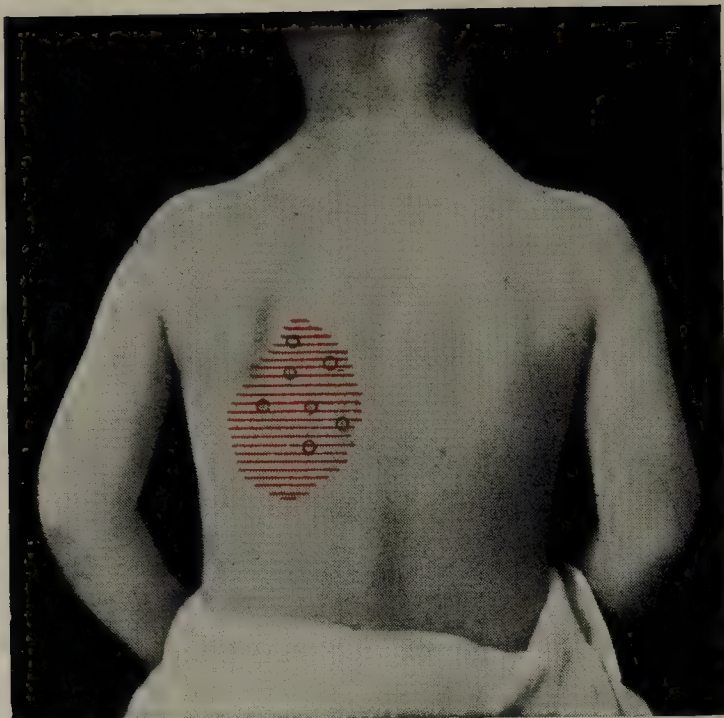


FIG. 54.—FIRST STAGE; CONGESTION OF LEFT LOWER LOBE, WITH CREPITANT RÂLES.

Feeble breathing of a rough character, with slight dulness.

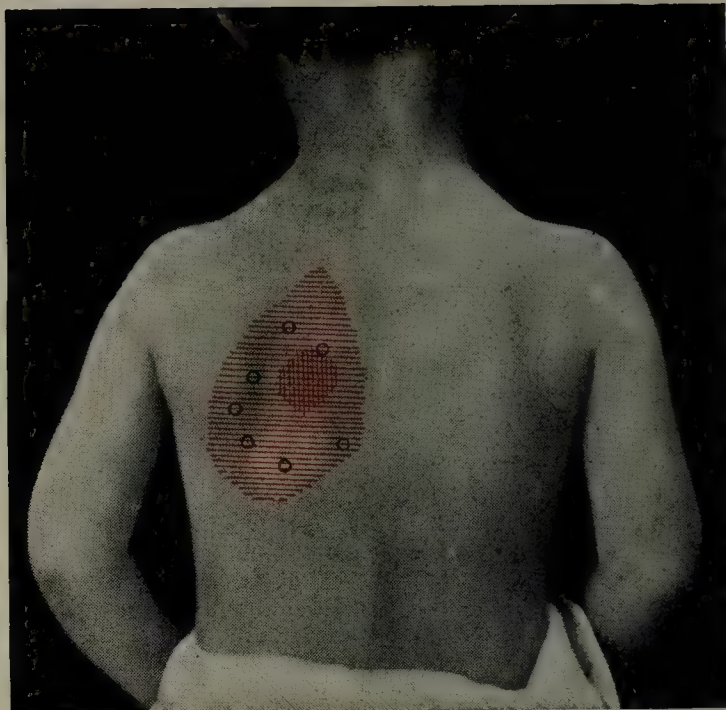


FIG. 55.—FIRST OR SECOND STAGE.

In the center of the area, a small spot of pure bronchial breathing and voice; surrounding this an occasional crepitant râle, with bronchovesicular breathing and slight dulness.

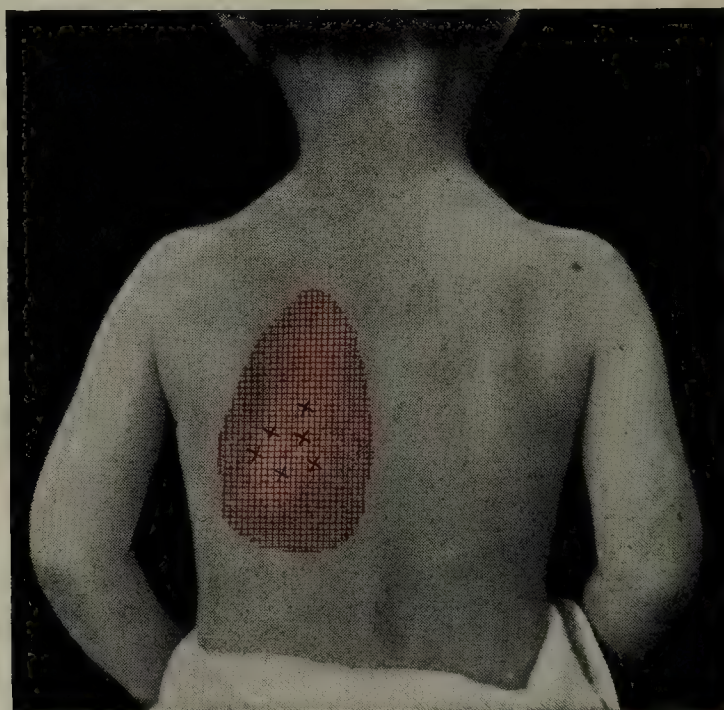


FIG. 56.—SECOND STAGE: COMPLETE CONSOLIDATION OF LEFT LOWER LOBE.

FIGS. 54-56.—PHYSICAL SIGNS IN LOBAR PNEUMONIA.

The small circles indicate fine râles; the red areas indicate consolidation partial or complete. The disease may stop at any one of these stages and resolution take place. During resolution the signs take the inverse order: those of Figure 56 give place to those of Figure 55, and these in turn to those of Figure 54. In addition many coarse râles may be heard.



In the second stage, that of consolidation, little air enters the air vesicles of the affected portion of the lung. There is found here exaggerated tactile fremitus, and marked dulness, often with a tympanitic quality, but not flatness. Over the rest of this lung there is exaggerated, sometimes even tympanitic, resonance; this is especially frequent at the apex of the lung in front, when there is consolidation

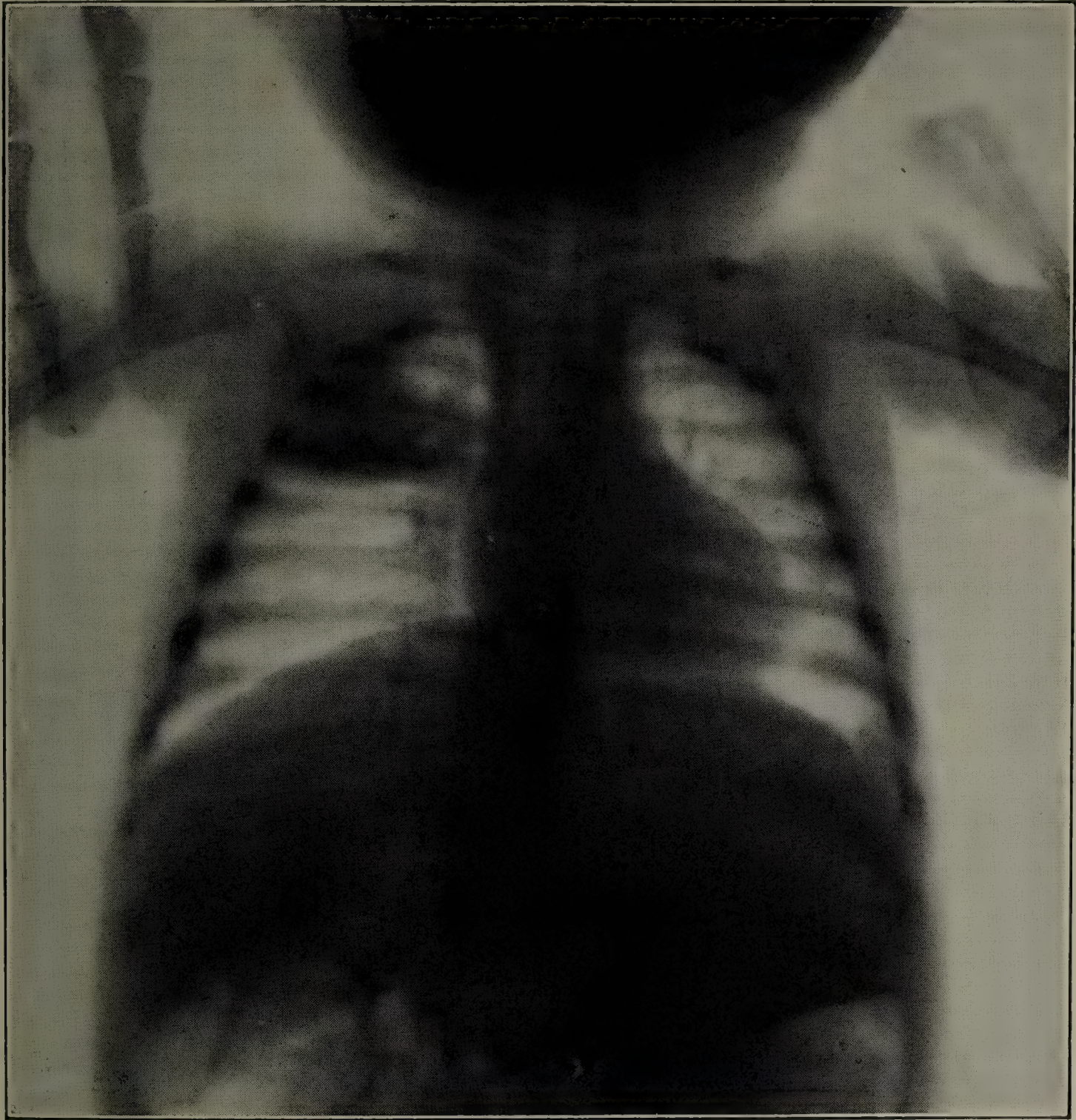


FIG. 57.—LOBAR PNEUMONIA.

Wedge-shaped involvement of the right upper lobe, at the height of the disease, with all of the usual signs of consolidation.

at the base behind. Under these conditions cracked-pot resonance may sometimes be obtained. Over the healthy lung there is exaggerated resonance. Over the consolidated portion there is bronchial breathing and bronchial voice, the area over which they are heard being sharply defined. Râles are usually absent, but there may be pleuritic friction sounds.

In the stage of resolution there is a gradual disappearance of the signs of consolidation. The pure bronchial breathing is replaced by bronchovesicular breathing, the vesicular element gradually predominating. Moist râles of all



varieties are heard. Usually the most persistent signs are slight dulness or diminished resonance, with a respiratory murmur which is feebler than normal and a little higher in pitch; sometimes there are also dry friction sounds. These signs may persist for two or three weeks.

*Exceptional Physical Signs.*—While in the majority of cases the signs of consolidation are distinct on or before the fourth day, in not a few they may be delayed much longer. In fully one-fourth of the cases signs of consolidation are not found before the fifth day, and they may not be present before the seventh or eighth day. These delayed signs were formerly explained by supposing the pneumonia to be at first central. Roentgen-ray studies have shown that it is the superficial rather than the central pneumonia that escapes detection. It is quite common in cases with late physical signs that the first distinctive evidences of disease are found high in the axilla, or beneath the clavicle in front, and these regions should be closely watched in all doubtful cases. Emphysema may mask the physical signs of consolidation.

**Complications.**—The occurrence of dry pleurisy over the consolidated portion of the lung is so constant that it can hardly be considered a complication. A slight serous exudation of two or three ounces is very common and often develops rapidly. This may or may not contain bacteria. It may clear up entirely or may go on to a true empyema. In the most severe cases of pleurisy there is an excessive exudation of fibrin and pus. This has occurred in about 8 per cent of our cases. This variety is known clinically as pleuropneumonia, and will be considered separately. A true purulent effusion may occur as early as the fourth or fifth day; more frequently it develops during the second week. Pericarditis is uncommon. It is seen more often in infants than in older children. It most frequently develops at the height of the pneumonia, rather oftener when this affects the left lung than the right; it occurs in pleuropneumonia much more often than in the simple form. The pericarditis is usually of the fibrinopurulent type. It may sometimes be discovered by physical signs, but rarely gives rise to any new symptoms. Endocarditis is extremely rare, though now and then it occurs upon valves previously the seat of a chronic lesion. Otitis due to pneumococcus is common in acute pneumonia. At times it is complicated by mastoiditis. Meningitis is rare, and generally develops late in the disease. It is nearly always ushered in by repeated attacks of vomiting or convulsions. Its course is short and progressive. Peritonitis causes few new symptoms except abdominal distention, pain, tenderness and occasionally vomiting. Arthritis and parotitis are very rare and are easily recognized. Jaundice may occur in the more toxic cases of pneumonia. It is often associated with focal necroses in the liver. An infrequent complication is the sudden development of acute cerebral symptoms with localizing signs. This may be due to hemorrhage, thrombosis or a localized abscess. Sometimes the symptoms clear up entirely; in other instances a residuum remains.

**Course and Termination.**—In the great majority of cases lobar pneumonia terminates either in perfect recovery or in death. When ending in recovery, resolution commonly begins immediately upon the cessation of the fever, and is complete in about a week. Delayed resolution is not common in children; chronic pneumonia and active tuberculosis are rare sequelae, but empyema is relatively



frequent. Its symptoms sometimes develop immediately after the pneumonia, the temperature continuing high; or there may be an interval of a few days before the development of the pleural symptoms. Some pleuritic adhesions probably remain in most cases in which there has been much dry pleurisy, and when severe and extensive, these may be the cause of subsequent symptoms, like any other dry pleurisy.

Death from uncomplicated pneumonia may be due to toxemia, or to circulatory failure, with or without failure of the respiration. The signs of circulatory failure sometimes develop quite rapidly in cases which are apparently doing well. The symptoms are: coldness of the hands and feet, then of the legs and arms; a rapid, compressible, and sometimes irregular pulse; muscular weakness and pallor, but usually no cyanosis. The symptoms of respiratory failure are: very rapid superficial respirations, sometimes 100 a minute; blueness of the lips and finger nails; often a leaden hue of the whole body; there are loud tracheal râles, and recession of all the soft part of the chest on inspiration.

Death may occur early in the disease, when the pneumonia has spread rapidly, involving both lungs. In most of the uncomplicated fatal cases, death results from circulatory failure at about the end of the first week. In the complicated cases death usually occurs in the second week; but we have known fatal meningitis to develop as late as the end of the fourth week. Peritonitis may develop as late as the third or fourth week.

**Diagnosis.**—In the majority of cases the symptoms are plain and the physical signs so typical that it is difficult to overlook pneumonia if any degree of care is used in the examination of the patient. The difficulties in diagnosis are due to the great variation in the general symptoms, and to the late appearance of the physical signs. The error usually made is to mistake pneumonia for some other disease, rather than to mistake some other disease for pneumonia. On account of its frequency in children, pneumonia should always be excluded before accepting any other explanation of a continuously high temperature. The rule should be followed, in all cases of acute illness, of making a thorough examination of the chest daily until the diagnosis is clear. If, to high temperature, a rapid respiration and marked leukocytosis are added, one should always suspect pneumonia, no matter what the other symptoms may be. It not infrequently happens that the general symptoms are quite characteristic and yet the physical signs appear late. In such cases pneumonia should always be looked for high in the axilla or just beneath the clavicle.

In their onset, scarlet fever, tonsillitis, and many acute infections may resemble pneumonia. From all other general diseases, pneumonia is to be differentiated especially by the physical signs. The differential diagnosis between lobar pneumonia and appendicitis is discussed under the latter disease.

Pneumonia with marked cerebral symptoms may resemble cerebrospinal meningitis. In both there may be an abrupt onset, convulsions, delirium or stupor, opisthotonos, prostration, marked leukocytosis, *tache cérébrale*, and, in young infants, fullness of the fontanel. The only positive means of differential diagnosis are the physical signs in pneumonia, and the findings from lumbar puncture in meningitis.

The question sometimes arises in pneumonia with cerebral symptoms, whether



or not pneumococcus meningitis also exists. If the nervous symptoms are present from the beginning, there is probably no meningitis. If they develop suddenly during the course or toward the close of the disease, meningitis should be suspected.

Lobar pneumonia is to be differentiated from a pleuritic effusion. The most common mistake is to confound empyema with unresolved pneumonia. In pneumonia rarely do the signs point to involvement of an entire lung. There is increased tactile fremitus, dullness, bronchial voice and breathing, and occasional râles or friction sounds. In empyema the physical signs indicate involvement of the whole side of the chest, there is displacement of the heart, flatness on percussion, diminished or absent tactile fremitus, and although bronchial voice and breathing are present, they are usually distant and feeble. There are no friction sounds, and râles are generally absent. In doubtful cases an exploratory puncture should always be made.

Tuberculosis sometimes gives rise to difficulties in diagnosis. The massive shadows that sometimes occur in this disease are more likely to be central than peripheral. In tuberculosis the symptoms and physical signs are usually far less striking than one would be led to expect from the size of the consolidation as revealed by x-ray. Although the acute splenic tumor of pneumonia may cause the spleen to become palpable, marked enlargement of the liver and spleen suggests tuberculosis. The specific tuberculin tests may be helpful, especially in young subjects. Occasionally only the course of the infection will enable one to decide. The most confusing cases are those in which an acute pneumonia develops in the presence of tuberculosis.

The x-ray may be of marked assistance in diagnosis. The shadow of consolidation in lobar pneumonia is usually clear and sharply circumscribed. It is often wedge-shaped as shown in Figure 57.

**Prognosis.**—There is probably no disease in which the patient appears so ill, and yet so often recovers completely, as lobar pneumonia in children over three years old. Of 1482 cases taken from hospital practice there were 60 deaths, a mortality of 4 per cent. In nearly all our cases death was due either to complications or to very extensive disease, as when both lungs were involved, or nearly the whole of one lung. In only one case was an uncomplicated pneumonia of a single lobe fatal.

The prognosis depends upon the age of the patient, the intensity of the infection, as shown by the temperature, nervous symptoms and pulse, the presence or absence of complications, and the extent of the local disease. These factors are to be taken into consideration rather than any special symptoms. The occurrence of vomiting, diarrhea, or marked tympanites late in the disease is always unfavorable.

A temperature range between 102° and 105° F. is the rule, and within these limits the fever does not affect the prognosis. Even very high temperature does not increase the danger from the disease as much as might be expected. Of 15 cases in which the temperature reached 106° F. or over, only 3 were fatal; while of 6 cases in which it was 106.5° or over, only 1 was fatal. The highest recorded temperature in our cases—107.5° F.—was in a patient who recovered.



A transient rise, even though the temperature may go very high, is seldom serious. Much more serious is a fever which remains steadily above 105° F., as in most cases this accompanies either very extensive disease or pleuropneumonia. The continuance of the fever after the tenth day is a bad symptom; such a prolonged temperature is an indication of a new focus of disease or the development of complications. If resolution does not begin within a day or two after the temperature becomes normal, the development of empyema, or some other pulmonary complication, should be suspected.

The results of blood cultures have some prognostic value. Of 108 hospital cases the mortality of 15 with positive cultures was 33 per cent; of 93 with negative cultures it was but 8 per cent.

**Treatment.**—This will be discussed together with Lobular Pneumonia.

#### REFERENCES

See page 460.



## CHAPTER XLVI

### LOBULAR PNEUMONIA

Lobular pneumonia (primary disseminated pneumonia) is essentially the pneumonia of infancy. The majority of cases of primary pneumonia in the first two years are of this variety. We have adopted this term, in the absence of a better one, in order to differentiate the process from interstitial bronchopneumonia, which is essentially a secondary process with a different bacterial flora and different pathological changes. The bacteriology is identical with that of lobar pneumonia. There is no adequate explanation at the present time for the production by the same group of organisms of inflammatory changes in the lung, widely disseminated in the one case and sharply circumscribed in the other, even though there are intermediate stages between the two and the products of inflammation are the same. Age must be reckoned as an important factor in determining the character of the process. The mortality from the disseminated form of primary pneumonia is much higher than from the localized form, probably because of the tender age of the patients in whom the lobular forms occur. The seasonal incidence is the same.

The same influences are operative as with lobar pneumonia. As an exciting cause, exposure to cold must still be classed among the potent factors of primary pneumonia. Some type of the pneumococcus is the usual exciting cause. Associated with it may be other bacteria, staphylococci, influenza bacilli, etc.

**Pathology.**—In the great proportion of the cases extensive lesions are found in both lungs. The parts most affected are, as a rule, the lower lobes posteriorly; next, the posterior part of both the upper and lower lobes. The left lower lobe is often more extensively diseased than the right.

There are a certain number of cases which follow tolerably well-defined stages of congestion, consolidation, and resolution; but the disease may be arrested at any of the stages and the child recover, or death may occur at any stage and at autopsy different portions of the lung representing all the stages mentioned may be found. It seems best, therefore, to describe the condition in which the lungs are found at the various periods when death is likely to occur, rather than to attempt to describe the different stages of the disease.

In the cases severe enough to cause death in the first twenty-four to forty-eight hours, very little can be seen by the naked eye, except acute congestion. The vessels of the pleura are distended, and there may be small superficial hemorrhages. Both lower lobes are usually heavy and dark-colored. There is to the naked eye no consolidation. All, or nearly all, the lung can be inflated. On section, there is found intense congestion with some edema. When the process has lasted a little longer the affected areas are more sharply defined. These, usually the posterior portions of both lungs, are of a brownish-red color, and there are numerous small



areas of consolidation. After section, blood and edematous fluid cover the surface of the lung and flow from the divided bronchi.

The microscope alone reveals the fact that these are not cases of simple pulmonary congestion or bronchitis of the finer tubes. In one case in which death occurred twelve hours from the first symptoms, well-marked evidences of beginning consolidation were found. In these hyperacute cases, there may be seen great distention of all the small blood vessels of the affected area, and small or large extravasations of blood just beneath the pleura and into the alveoli. In some cases these hemorrhages form the most striking feature of the lesion. The air vesicles are partially, some almost completely, filled with red blood cells, desquamated epithelial cells, little or no fibrin and a few leukocytes. The red blood cells predominate. The inflammation may be diffuse or occur in numerous discrete areas. The mucous membrane of the large and small bronchi is the seat of catarrhal inflammation. The interstitial tissue of the lung is unaffected.

When the disease has lasted several days there are usually found at autopsy numerous small areas of consolidation and perhaps one or more large ones which may affect nearly an entire lobe, so that at first sight the lesion may resemble lobar pneumonia. The extent of these areas depends largely upon the duration of the disease. In most cases there is pleurisy over the consolidated portions. The surface of the lung is usually of a mottled red and gray color; it often has a coarsely irregular feel, due to the consolidation of some of the superficial lobules of the lung. On section, it is rarely found that an entire lobe is consolidated, the superficial portion being most affected, while the central part may be normal or only congested. The color is mottled, due to reddish or grayish or slightly yellowish areas which are raised above the surrounding lung. These areas are dry, sometimes granular, and are separated from each other by normal pulmonary tissue. They are often surrounded by hemorrhagic zones. The areas of consolidation encompass many lobules and may not be limited by interlobular septa, but they are not in immediate relation with bronchi, and the walls of the latter and the interlobular septa are not thickened. With the microscope the alveoli are seen to be filled with leukocytes, fibrin, more or less blood and many organisms, chiefly pneumococci. The pulmonary tissue itself is intact. Resolution takes place as it does in lobar pneumonia; the products of inflammation disintegrate and are gradually absorbed.

**Associated Lesions of the Lungs.**—*Pleurisy* is usually found over large areas of consolidation and in cases of more than four or five days' duration, while in most of those fatal within the first few days the pleura is normal or only congested. It is seen in all grades of severity, from a slight gray film of fibrin that can hardly be stripped off, to a yellowish-green exudation one-fourth of an inch thick. A small amount of serum—two or three ounces—in the pleural cavity is common, but a large serous effusion is very rare. Cases in which there is an excessive fibrinous inflammation of the pleura are considered elsewhere under the heading of Pleuropneumonia. Empyema occurs both during the stage of acute inflammation of the lung and also while this is subsiding, but it is less frequent than in lobar pneumonia.

*Bronchial Nodes.*—In all the recent acute cases these are swollen and red; the usual size is that of a pea or a bean. Microscopically the usual changes of acute



hyperplasia are seen. In protracted cases, and after repeated attacks, they may be two or three times the size mentioned, and of a gray color.

**Symptoms.**—There is greater variation in the course of disseminated primary pneumonia than there is in that of the localized form. The cases differ from each other very markedly, but they may be divided into a few quite distinct groups.

*The Acute Congestive Type.*—This may be seen at any age, but is more frequent in young infants. Its symptoms are few and irregular, and the disease is often unrecognized. The entire duration may be only twenty-four hours. High temperature, extreme prostration, cyanosis, and rapid respiration may be the only symptoms. The temperature varies between 104° and 107° F., usually rising steadily until death occurs. The prostration is extreme from the outset, the patient being overwhelmed by the suddenness and severity of the attack. Cyanosis is frequently present, and almost always so shortly before death. The respirations are from 60 to 80 a minute, but in most cases not strikingly labored. Cough is frequently absent. Cerebral symptoms are often marked—dullness and apathy, sometimes quite profound stupor, and not infrequently convulsions just before death. The physical signs are few and inconclusive. There is often nothing abnormal except very rough breathing over both lungs behind; sometimes the breathing on one side is feeble, and on the other much exaggerated. There may be no râles whatever, and little or no change in the percussion note.

The suddenness and severity of these symptoms are something which it is hard for one who has not observed them to appreciate. We have known an infant to die in twelve hours from the time in which he was apparently in perfect health, and we had opportunity to confirm the diagnosis of pneumonia by a microscopical examination of the lung. The diagnosis cannot be positively made during life, and in most of the cases the disease passes under some other name.

If the children are sufficiently strong to withstand the onset of violent symptoms, they may recover completely in four or five days, the lung clearing up very rapidly. In other cases these grave symptoms may abate in a day or two, to be followed by those of the ordinary form, which runs its usual course.

The symptoms of some of these cases may be explained by the sudden intense engorgement of the lung, which, owing to the small size of the air vesicles, interferes with its function almost as much as does consolidation. In other cases the symptoms are due not so much to the pulmonary condition as to an accompanying septicemia. These cases may be fatal in two or three days, postmortem cultures showing pneumococci or other organisms in the blood and organs.

*Lobular Pneumonia of the Common Type.*—This usually begins abruptly with symptoms not unlike those of lobar pneumonia. This is the mode of onset in about two-thirds of the cases. In only about 10 per cent is the pneumonia preceded by clear evidences of bronchitis. In these, the symptoms of bronchitis may slowly or rapidly merge into those of pneumonia. When the onset is sudden it is marked by high fever, frequently by vomiting, rarely by convulsions. In addition there are rapid respiration, cough, prostration, and sometimes cyanosis. The symptoms are more distinctly pulmonary than is generally the case in lobar pneumonia.

The temperature, as a rule, is high; rarely is it continuously so, but it is of a remittent type. The daily fluctuations often amount to three or four degrees. The



fever usually continues from one to two weeks, and subsides gradually rather than by crisis, though crises are by no means rare. Although, as a rule, we expect a high temperature with acute pneumonia, this is not invariable. Cases may run their course, and even terminate fatally, although the temperature has not been above 101° F. A low temperature is more often seen in young and delicate infants than in those who are older and more robust.

The respirations are frequent and labored; there is real dyspnea. On inspiration, there is marked recession of all the soft parts of the chest, and the alae nasi dilate actively. The usual rapidity of the respirations is from 60 to 80 per minute; very often, however, it rises to 100, and on several occasions we have seen it even 120. Respiration generally seems more embarrassed than does the action of the heart, and respiratory failure is a more frequent cause of death than circulatory failure. The pulse is always rapid—from 150 to 200 a minute—and when so it is sometimes irregular. The pulse rate is of much less importance than its character. Early the pulse is full and strong, but soon it becomes soft, compressible, and weak.

The prostration is usually moderate for the first day or two, but steadily increases as the lung becomes more and more involved, and toward the close of the disease may be extreme.

Cough is much more constant than in lobar pneumonia, and more distressing; sometimes it is almost incessant. It disturbs rest and sleep, and may cause vomiting if the paroxysm occurs soon after eating. There is no expectoration. Mucus is sometimes coughed up into the trachea, or even into the pharynx, to be swallowed again, or, more frequently, aspirated into the lung. If during a severe paroxysm the patient is turned upon his face or inverted, much of this mucus may be dislodged. A strong cough is a good symptom; suppression of the cough is unfavorable.

Pain in the chest is not common, and is rarely an annoying symptom. There may be hyperesthesia of the chest wall. Cyanosis is present at some time in the most severe cases. It may occur at the onset, or at any time during the course of the disease. Even when slight, it is always a danger signal, and when present, if only in the finger tips or lips, indicates that the patient must be carefully watched. This is an indication for the use of oxygen.

Nervous symptoms at the onset are not so common as in lobar pneumonia, convulsions being rare; but late convulsions are frequent, and when present the disease is usually fatal. Delirium may occur at any time during the attack. In infants this shows itself by excitement and inability to recognize the nurse or mother. As elsewhere stated, the nervous symptoms depend less upon the location of the disease than upon its extent, the intensity of the infection, and the susceptibility of the patient.

Gastro-enteric symptoms are frequent in infancy, and are of much importance. Often there are from four to six stools a day, of a green color, containing mucus and undigested food. These symptoms depend upon the feeble digestion which is associated with the febrile process, and are often aggravated by improper feeding and overmedication. Vomiting and diarrhea add much to the danger of the attack. In summer this complication is more frequent and is likely to be more severe.



Distention of the stomach or intestines from gas may be the cause of distressing symptoms, owing to the added embarrassment of respiration produced by this upward pressure. In infants it may lead to attacks of cyanosis.

The blood often shows a moderate secondary anemia, which in protracted cases becomes very marked. A leukocytosis is almost invariably present. In an average case this ranges from 20,000 to 40,000. It sometimes is excessively high without any apparent reason. We have several times seen it over 100,000. The increase is chiefly in the polymorphonuclear cells, which usually form from 60 to 85 per cent of the total leukocytes. With the fall in temperature the leukocytes in most cases are rapidly reduced. A rapid diminution in the leukocytes may indicate a marked loss of resistance in the patient, and may be seen with either a high or a low temperature.

Positive blood cultures are obtained in a somewhat higher percentage of cases than in lobar pneumonia.

The urine in most cases is scanty, high-colored, and loaded with urates. A trace of albumin is often present when the temperature is very high; but casts, renal epithelium, and a large amount of albumin are rare.

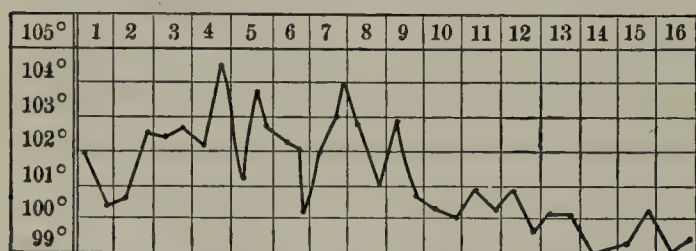


FIG. 58.—TEMPERATURE CURVE IN TYPICAL LOBULAR PNEUMONIA OF THE Milder Form.

Male, sixteen months old; delicate child; previous bronchitis; onset gradual; signs of consolidation at left base on fifth day, but fine râles over both lower lobes behind; resolution slow, râles persisting for a long time in both lungs.

when there was a return of the fever, accompanied by new signs in the chest, the second attack being shorter and milder than the first. Very often the temperature falls to normal without any signs of resolution, and after an interval varying from two or three days to a week there is a recurrence of the fever and other constitutional symptoms, the second attack frequently proving fatal.

**PHYSICAL SIGNS.**—In considering the signs, it is better to connect them with the different conditions in the lung than to group them in stages, as in lobar pneumonia.

**Without Consolidation.**—It cannot too often be repeated that lobular pneumonia may exist without signs of consolidation at any period during the course of the disease. The earliest signs are due to congestion of the lung associated with bronchitis of the smaller tubes, which is usually localized, but which may be general. Congestion of the lung causes feeble breathing over the affected area and slight dulness or diminished resonance. With this are found coarse sonorous, and finer sibilant râles, due to congestion and swelling of the mucous membrane of the

The temperature chart shown in Figure 58 is a good example of a very frequent course of primary disseminated pneumonia of moderate severity terminating in recovery. In cases of this type the constitutional symptoms are not grave, and follow very closely the temperature curve.

In more severe cases the temperature is higher, often fluctuates widely and the course may be prolonged for two or three weeks.

The chart shown in Figure 59 is that of relapsing pneumonia. Resolution had begun, and was apparently progressing favorably,



larger and smaller bronchi respectively. These signs are soon replaced by very fine moist râles, which are usually localized in one of the lower lobes behind (Fig. 60). These localized fine râles are the first distinctive sign of pneumonia. Soon a change in the respiratory murmur is heard in the affected area, which becomes feebler but higher in pitch. Elsewhere in the chest there may be coarse râles, due to bronchitis of the large tubes. The case may go on to recovery without presenting anything more distinctive than the signs mentioned.

With Areas of Partial Consolidation.—In the lung at this time such areas are generally superficial and separated by healthy or congested lobules. Percussion may give negative results or there is slight dulness. The tactile fremitus is not usually altered. Fine moist râles may be heard over quite a large area, but at some point, usually near the spine, over one of the lower lobes, they are sharper, louder, higher pitched, and more metallic, and seem close under the ear (Fig. 61). Respira-

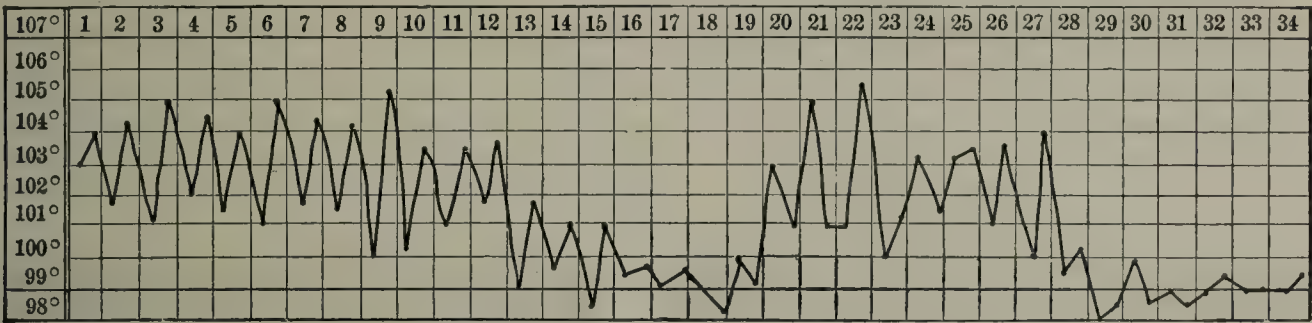


FIG. 59.—TEMPERATURE CURVE OF RELAPSING LOBULAR PNEUMONIA; RECOVERY.

Male, nineteen months old; delicate. Consolidation on sixth day in left lower lobe behind; two days later small area of consolidation in right lower lobe behind; many râles both sides; eighteenth day, signs of consolidation had disappeared but many râles persisted. Accession of fever on nineteenth and twentieth days, accompanied by extension of disease as shown by new râles, but no evidence of consolidation during second attack. Slow resolution and convalescence.

tion is feebler here than elsewhere, and bronchovesicular in quality, approaching bronchial breathing more and more as the consolidation increases. The resonance of the voice and cry is exaggerated.

With Areas of Consolidation More or Less Complete.—On percussion there is dulness, but surprisingly little in comparison with the other signs of consolidation present. It is due to the fact that the consolidated portion, though extensive, may not involve the lung to any great depth, and also that there are in the consolidated area many alveoli which still contain air. On palpation there is usually a slight increase in the tactile fremitus. On auscultation, there are still present the evidences of bronchitis, usually only behind, but sometimes over the entire chest. Coarse and fine râles are intermingled. Over the consolidated parts are heard bronchial breathing and bronchial voice. At the center of these areas the bronchial breathing is pure and râles are usually absent, but at the margin râles are present and the breathing approaches the bronchovesicular type (Fig. 62). The signs of consolidation are rarely sharply circumscribed as they are in lobar pneumonia, but shade off gradually. The consolidated area is at first small, but may gradually extend until nearly the whole of one or even both lungs behind are more or less completely solidified (Fig. 63). The signs are found as far forward as the axillary line, but usually stop there. Friction sounds may be heard over the consolidated areas, but very rarely except where signs of complete consolidation are present. It is often



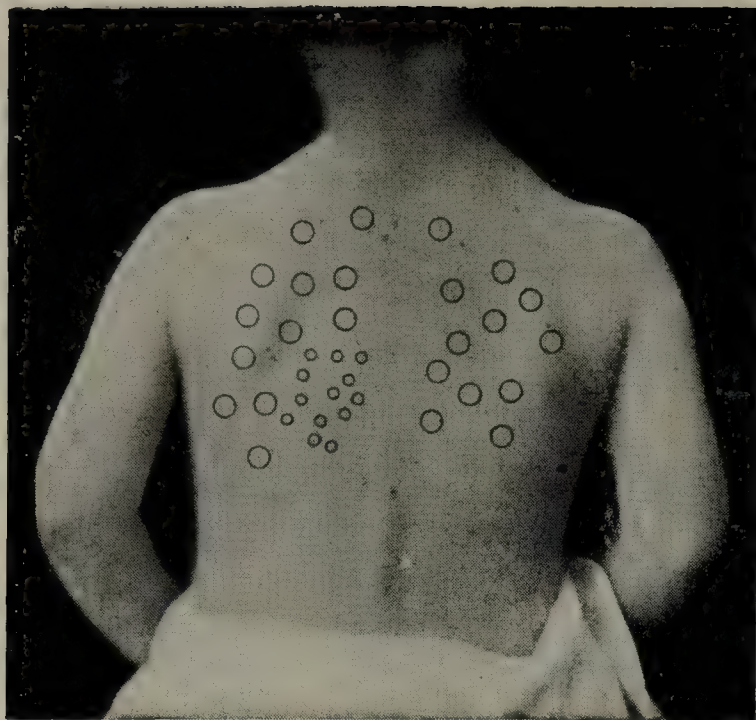


FIG. 60.—FIRST STAGE.

Coarse râles over both lungs; localized fine (subcrepitant) râles at the left base. No change in breath sounds.



FIG. 61.—SECOND STAGE.

Coarse and fine râles over both lungs behind; at left base an area of partial consolidation, with bronchovesicular breathing, exaggerated voice, and very sharp râles.

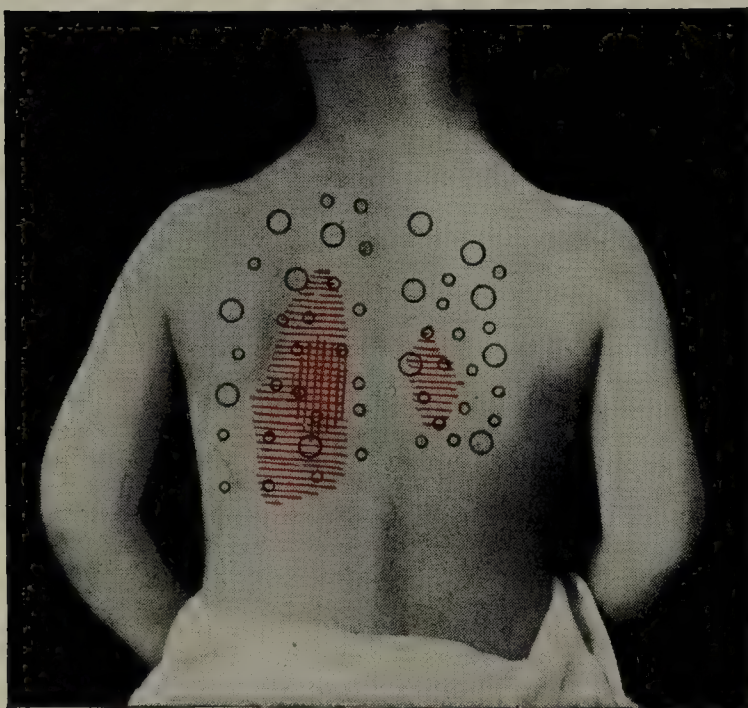


FIG. 62.—THIRD STAGE.

A larger area of partial consolidation, and in the center a small area of complete consolidation, with bronchial breathing and voice and slight dulness. Signs over the right lung similar to what were previously present over the left.



FIG. 63.—FOURTH STAGE.

Extensive disease of both sides; large area of complete consolidation on the left, with dulness, bronchial breathing and voice, and no râles; surrounding this, bronchovesicular breathing, with many râles. Signs in the right lung similar to those previously present over the left.

#### FIGS. 60-63.—PHYSICAL SIGNS IN LOBULAR PNEUMONIA.

The large circles indicate coarse râles; the smaller ones, finer râles; the red areas indicate consolidation partial or complete. The disease may stop at any one of these stages and resolution take place.



impossible to obtain any idea of the condition of an infant's lung during quiet, superficial respiration. Sometimes over a part which is completely consolidated there is heard only very feeble breathing, or the lung may be almost silent. If, however, the child is made to cry or to take a deep inspiration, both the bronchial breathing and râles are distinctly brought out. The intensity of the consolidation increases as the disease advances, and the signs become more and more like those of lobar pneumonia. During resolution the disappearance of the signs of consolidation may be quite rapid, but râles often persist for several weeks.

Signs of consolidation are seldom obtained until the third or fourth day, and in many cases not until later.

In general, it must be borne in mind that in many cases signs of consolidation are never present, as the areas of pneumonia are small and widely scattered; that consolidation is usually incomplete, because there are areas of healthy lung between the hepatized portions; that the signs of consolidation usually shade off gradually; and that both sides are almost invariably involved, although one side usually to a greater degree than the other.

*The Protracted Form.*—This is seen especially among young and delicate children. The onset and course of the disease for the first week or two do not differ from an ordinary attack of moderate severity, but at the end of this period there is seen no tendency in the process to subside. The fever continues, although it may not be high, but by physical examination it is found that the areas of consolidation are gradually increasing day by day, until sometimes the greater part of both lungs behind are involved.

There is continued wasting and steadily increasing prostration. The appetite is lost and vomiting is easily excited. Purpuric spots may appear upon the abdomen. Death takes place from asthenia, seldom from a rapid extension of the disease to a portion of the lung previously uninvolved. Although most patients with prolonged pneumonia die, some apparently hopeless cases end in recovery. The temperature falls to normal, gradually the appetite returns and the child gains weight and strength. It is a long time, however, before the physical signs disappear or health is permanently established.

*Capillary Bronchitis.*—This condition is conveniently considered in the present connection, for in most of these cases evidences of pneumonia are to be found postmortem. The symptoms, however, are chiefly due to a bronchitis which extends to the smallest tubes. Fibrinous exudate, and in some cases edema, causes obstruction with great respiratory distress.

These cases are not very common. The onset is acute, with fever, very rapid and labored breathing, severe cough, moderate prostration, and in most cases cyanosis. The temperature is not high, usually only from 100° to 102° F., and it often continues so for three or four days. The pulse is rapid, and at first is full and strong. The respirations are exceedingly rapid, often from 80 to 100 a minute. There is marked dyspnea with recession of all the soft parts of the chest during inspiration. Cough is always present, usually severe, and sometimes almost incessant. The prostration is not so great as in the cases previously described, and the development of the symptoms is much less rapid.



There are at first sibilant and afterward subcrepitant râles over the entire chest, with which are usually mingled coarser moist râles. There are no evidences of consolidation. The respiratory murmur is everywhere feeble, but not otherwise altered. Percussion generally gives exaggerated resonance, owing to the emphysema which is present, the note being sometimes almost tympanitic.

The symptoms may gradually increase in severity until death takes place, by the third or fourth day, from respiratory or cardiac failure. There is usually marked cyanosis, and toward the end rapidly increasing prostration. Just before death the temperature often rises rapidly to 106° or 107° F. At autopsy, in addition to the pneumonia, the lungs are generally found in a state of hyperinflation and therefore do not collapse on opening the chest. There may be, in addition, extensive congestion or edema, the development of which has been the immediate cause of death.

In cases which do not prove fatal there is usually by the third or fourth day great improvement in the general symptoms; the finer râles may disappear, and the coarse ones become more and more prominent. By the end of a week there may be complete recovery. Instead of this, there may be a continuance of the constitutional symptoms, and disappearance of the fine râles in front only, while behind near the spine there are gradually added to them the signs of consolidation in one of the lower lobes. From this time the case may progress as one of ordinary primary pneumonia.

Oxygen is always indicated in such cases. Steam inhalations in a croup tent may be of help and epinephrine should be tried.

**Complications.**—Most of those relating to the lungs have been described with the lesions. Pleurisy will be separately considered. Pulmonary emphysema is always present to a greater or less degree, but cannot usually be recognized by physical signs. Pneumothorax occurs even in infancy, but is very infrequent except as a result of puncture of the chest. Otitis is exceedingly common, and one should be constantly on the lookout for it. It is recognized only by examination of the ear with a speculum.

Meningitis may complicate acute disseminated pneumonia. It has occurred in about 2 per cent of our cases. It is in all respects similar to that occurring with lobar pneumonia. Meningeal hemorrhage we have seen only once, and it was the cause of death in a patient eleven months old, who a few days before was seized with convulsions, followed by a gradually increasing stupor, which continued until death. The hemorrhage covered the entire convexity of the brain. Thrombosis of the sinuses of the dura mater and of the meningeal veins is an uncommon complication. It may cause no symptoms, the condition being found postmortem. Occasionally it produces severe and repeated convulsions. Endocarditis is extremely rare; it was not observed in any of our cases. Acute pericarditis is also rare unless there is an extensive pleurisy. When it occurs it is usually with pneumonia of the left side. Complications referable to the digestive tract are quite common. Herpetic stomatitis is frequent, and occasionally the ulcerative variety is seen. Thrush often occurs in the protracted cases among very young infants. Pathological changes in the intestines are not common, considering the frequency of vomiting and diarrhea. Nephritis is rare and very seldom severe enough to affect the prognosis.



Old lesions of tuberculosis, cheesy nodules in the lungs and sometimes in the pleura, are not infrequently encountered in patients dying of acute pneumonia of a nontuberculous character.

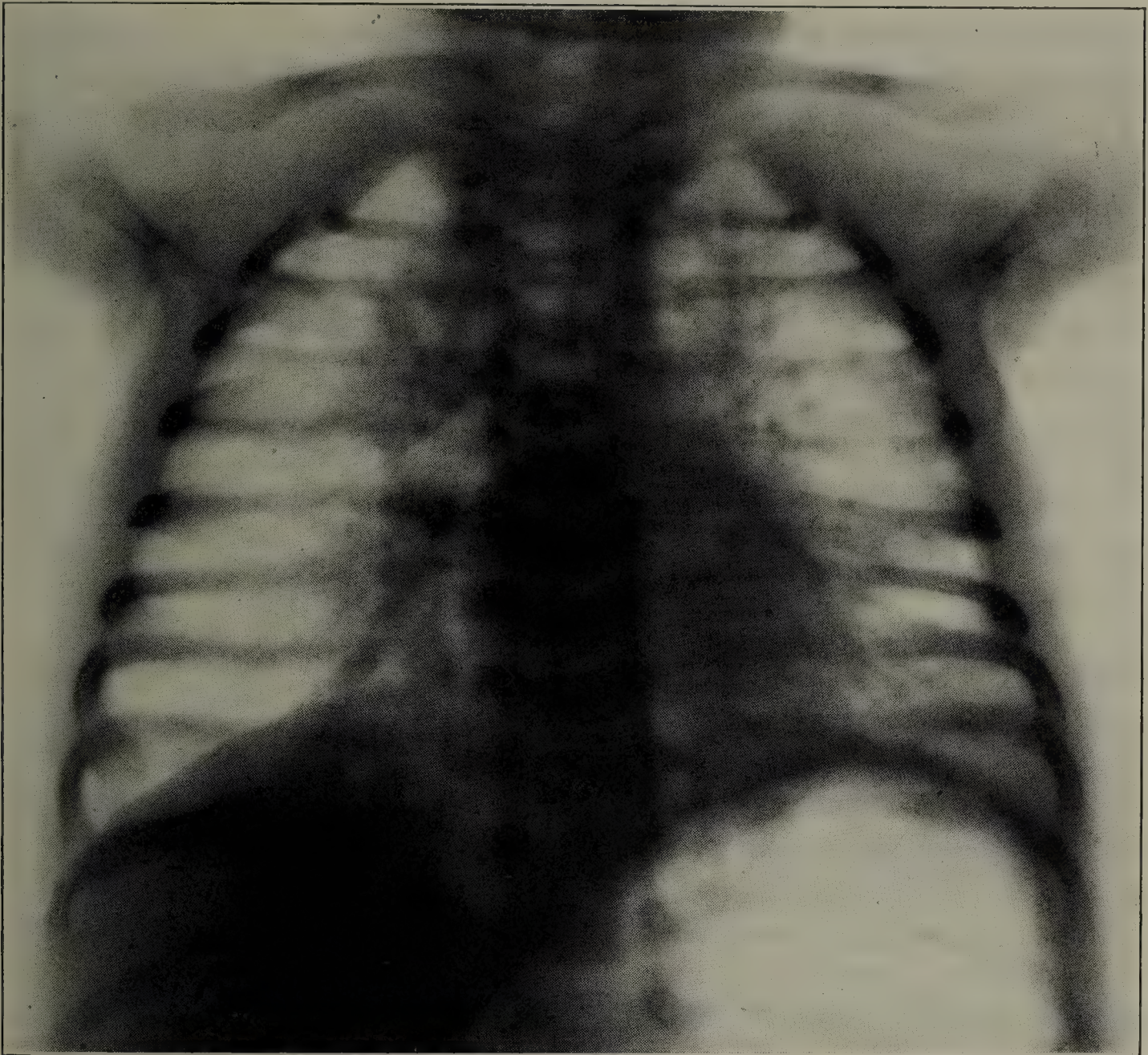


FIG. 64.—ROENTGENOGRAM IN LOBULAR PNEUMONIA, SHOWING AN INCREASE IN BRONCHOVASCULAR MARKINGS AND PATCHY AREAS OF INCREASED DENSITY IN THE MEDIAL PORTION OF THE PULMONARY FIELDS.

Alexander G. (B.H. 335686), age five weeks, was a premature infant, weighing four pounds, fourteen ounces at birth. He had been entirely breast fed. At the age of four weeks he developed a cough and vomited repeatedly. Five days after onset of the cold he began to have spells of cyanosis and was brought to the hospital. He weighed only five pounds, four ounces on admission and was blue and feeble. There was a mucopurulent discharge from the left nostril, and the left ear drum was congested. The lungs were normally resonant but showed patches of harsh breathing with fine râles posteriorly. The temperature was 100.2° F. and the leukocyte count 10,300, with 69 per cent polymorphonuclears. For ten days he continued to run a mild fever, seldom over 101° F., but required constant administration of oxygen to control the cyanotic attacks. Gradually his condition improved and the signs in the chest cleared. There was virtually no change in the white blood count. He was discharged after three weeks, entirely free from cough and cyanosis and having gained seven ounces in weight.

**Diagnosis.**—An acute onset with continuous high fever, rapid respiration, and cough, should always lead one to suspect pneumonia. When to these symptoms are added prostration and a polymorphonuclear leukocytosis, the diagnosis of pneumonia is almost certain. Cases of the acute congestive type are the ones most



frequently unrecognized. Many atypical cases of pneumonia are seen, particularly in young infants. An unusual febrile reaction is perhaps the symptom most likely to lead to a mistake. While this, as a rule, is high and remittent, sometimes it is not so, and it may be but little above normal. Rapid respiration is almost always present, but cough may be very slight, especially in infants. In very young infants, the diagnosis often rests upon the prostration, cyanosis, and rapid respiration, the other acute inflammatory symptoms being absent. Only the physical signs of the disease can positively settle the question of diagnosis.

When pneumonia follows bronchitis of the large tubes, the extension of the disease to the lungs is usually marked by three symptoms: a steadily rising temperature, more frequent respiration, and increasing prostration.

At the outset, pneumonia may be indistinguishable from severe bronchitis. Such a bronchitis often begins with severe symptoms and a high temperature; but this is of short duration, usually falling after twenty-four or forty-eight hours to 100° or 101° F. The prostration is much less and all the symptoms, possibly excepting the cough, less severe. The only physical signs are coarse râles, which are heard throughout the chest.

The same rules apply to bronchitis of the smaller tubes. The râles are heard both in front and behind, and usually over both sides. If with such râles the temperature continues to rise for several days above 103° F., it may be assumed that pneumonia is present, provided there is no other disease which might explain the temperature. Acute localized bronchitis is to be interpreted as pneumonia, provided tuberculosis can be excluded.

The x-ray is of value in detecting the presence of consolidation before this can be discovered by physical signs (Fig. 64). Small scattered areas of pneumonia are often indistinguishable from tuberculosis. Large areas of consolidation do not differ in their appearance from those of lobar pneumonia. But in general the consolidated areas of disseminated pneumonia cast poor shadows.

**Prognosis.**—Disseminated pneumonia is always a serious disease, and in an infant dangerous to life. The prognosis depends upon the age, surroundings, and previous condition of the patient, and upon the severity of the infection. In private practice the mortality from disseminated pneumonia is from 10 to 20 per cent; in institutions it may be considerably higher than this, as is shown by the following table.

TABLE XXXIV  
MORTALITY RATE IN 346 INSTITUTIONAL CASES OF PRIMARY DISSEMINATED PNEUMONIA

Age	Cases	Percentage Mortality
During the first year .....	202	66
During the second year .....	102	55
During the third year .....	33	33
During the fourth year .....	6	16
During the fifth year .....	3	..

Probably the best of all guides to the nature and severity of the infection is the temperature. An excessively high temperature usually indicates a severe type



of infection. The outlook in cases with a steadily high temperature—between  $102.5^{\circ}$  and  $104^{\circ}$  F.—is usually more favorable than in those with wide fluctuations, such as  $100^{\circ}$  to  $105.5^{\circ}$  F. As a rule, the danger from the disease increases steadily with every degree of temperature above  $104.5^{\circ}$  F.

An important factor in the prognosis is the previous condition of the patient. The association with rickets is unfavorable, both on account of the feeble muscular power of these children and their thoracic deformities. Marked and persistent tympanites is always an unfavorable symptom.

In making the prognosis in any given case, the symptoms to be considered are the height and course of the temperature, the presence or absence of nervous symptoms, the condition of the organs of digestion, the presence of cyanosis and the extent of the disease as shown by the physical signs. We have not found the examination of the blood to aid greatly in prognosis. The leukocyte count varies widely and often without apparent reason. Blood cultures are of some assistance, but it is not so much the presence as the number of organisms in the blood that is of prognostic importance.

Convulsions occurring early in the disease do not affect the prognosis; but of 37 cases in which convulsions occurred at a late period all but 1 proved fatal.

So long as the nutrition of the patient can be well maintained, no protracted case is hopeless, no matter how extensive the local disease may be; but the existence of vomiting, diarrhea, or persistent tympanites makes the issue doubtful, even though the other symptoms are favorable.

**Treatment of Primary Pneumonia.**—The most important part of prophylaxis, an essential factor in treatment, is to give careful and early attention to every attack of bronchitis in an infant, for any such attack should be regarded as a possible precursor of pneumonia. It is striking that one sees pneumonia in infancy so seldom in private practice among the better-situated classes, even though bronchitis is very frequent, while among hospital and dispensary patients pneumonia is constantly seen.

The hygienic treatment of pneumonia is important and usually receives too little attention. Older children should be kept in bed. Infants should have their position changed frequently. No child should be allowed to lie for hours directly on the back. The general rules previously laid down for feeding all sick children should be observed here. As a rule medicine should not be administered in the food. Food should not be forced when the patient is suffering only from thirst. Water should be allowed freely at all times.

For older children there seems to be a decided advantage not only in fresh air, but in cold air. Patients in cold rooms or out of doors sleep better, cough less and altogether seem more comfortable than when carefully housed to prevent their "taking cold." In cold weather the child should be properly protected by blankets, a flannel wrapper, woolen stockings and with usually a hot-water bottle at his feet. Individual cases differ greatly in their response to cold; it is therefore desirable to watch the child closely at first to determine its effect. The cold air treatment is seldom effective with young and delicate infants or those with much bronchitis. The best results from this treatment are seen in vigorous children with extensive consolidation and with a minimum amount of bronchitis.



Counterirritation by means of mustard paste or poultices is annoying and of very doubtful value. Little can be lost and something gained by dispensing with them altogether. Most children with pneumonia receive too much treatment.

Primary pneumonia is a self-limited disease, having a strong tendency to recovery in the great majority of cases, regardless of the treatment adopted. The fatal cases are almost always in children under two years of age; the rare deaths in older ones are usually due to complications. It follows, therefore, that the indications are to make the patient comfortable during his illness, so far as possible, to watch for complications and to treat the individual symptoms as they arise.

The specific treatment of pneumonia due to pneumococcus Type I is seldom applicable to children. The determination of the type of pneumococcus, owing to unsatisfactory sputum collection, is far more difficult than it is with adults. The treatment itself is painful, produces considerable shock and must be frequently repeated. It produces so much terror and apprehension in a child as to make all nursing and treatment difficult. The mortality from infection with Type I pneumococcus is very low with children and there has yet been brought forward no evidence that in them it can be lowered by the use of antiserum. For these reasons we believe that it is wise not to attempt specific treatment in the pneumonia of childhood.

It should be remembered that the normal range of temperature in primary pneumonia is from 101° to 104.5° F. This temperature is not in itself exhausting and the chances of recovery are not improved by reducing it so long as it remains within these limits. Coal-tar products should not be used as antipyretics. In small doses they may be used to allay irritability and restlessness. To reduce persistently high fever (105° F. or over), especially when nervous symptoms are present, the most certain and safest antipyretic is cold. It may be used in the form of the cold pack, cold compresses, sponging or an ice-bag applied to the chest. Not all children bear cold well, and in its use and frequency of repetition one must be guided by the effect upon the child's general condition as well as upon the temperature.

Inhalations have no effect upon the local process and are seldom beneficial unless there is a harassing cough or much bronchitis. They may be tried in these circumstances as advised under the treatment of bronchitis.

Nervous symptoms, restlessness, lack of sleep, etc., are often best controlled by cold or tepid sponging; in other cases, especially if there is pain or incessant cough unrelieved by inhalations, by codeine or morphine.

Distention is a dangerous symptom and must be prevented. If this is extreme, food should temporarily be withdrawn, only broth and water being offered and a rectal tube passed or a small enema given. It may be necessary to restrict the food greatly for several days. Starchy food had best be reduced to a minimum though the distention is doubtless due to paresis of the intestine rather than to excessive fermentation.

In that form of pneumonia frequently called "capillary bronchitis" and in any event when cyanosis is present, oxygen is of great value. This should be introduced through a small catheter passed into one nostril as far as possible without producing the rhinopharyngeal reflex. The oxygen should bubble through a water trap



from a cylinder at the rate of twenty or thirty bubbles a minute. This may be continued for hours at a time. The result is often most satisfactory.

Alcohol has been greatly abused in this disease. Although in small quantities it appears to be of value at times, there is doubt as to its mode of action. Not over  $\frac{1}{2}$  ounce daily of whisky or brandy should be given to an infant of two years.

Transfusion is sometimes of apparent benefit in primary pneumonia. Given at the height of the fever, the temperature will often drop to normal within a few hours, where it may remain for twenty-four hours and then rise again. Sometimes it fails to rise again and one may suspect that a crisis was impending before the treatment was given. We are not convinced that in the absence of anemia transfusion is of value. If used, the quantity of blood should be small since there is danger of overloading the circulation.

The mechanism of circulatory failure in pneumonia is not clearly understood. If the circulation fails gradually, stimulants such as digitalis and caffeine may be used, the former by mouth in the form of a physiologically standardized preparation (leaves or tincture), the latter hypodermically. Too much should not be expected of their action. In sudden temporary failure nothing compares with epinephrine given intramuscularly in doses of 3 to 15 minims of a 1:1000 solution; atropine also used hypodermically is sometimes useful—dose  $\frac{1}{400}$ - $\frac{1}{200}$  grain. Oxygen should be employed. One should never declare a case of primary pneumonia hopeless.

#### REFERENCES

See references on page 460.



## CHAPTER XLVII

### INTERSTITIAL BRONCHOPNEUMONIA

Interstitial bronchopneumonia is probably always *secondary* but with children it may be difficult to recognize the primary disease on account of the mildness and inconspicuous character of the symptoms. This is especially the case with pertussis and with epidemic influenza. The term bronchopneumonia describes a lesion rather than a disease, several quite distinct forms of infection being included under this head. The mortality is high because of the tender age at which most of the cases occur and because it complicates many of the most severe forms of the acute infectious diseases of childhood. The chief differences between lobar or lobular pneumonia and interstitial bronchopneumonia are given in the accompanying table.

#### *Lobar and Lobular Pneumonia*

1. Practically always primary
2. Occurs in healthy, robust infants
3. Caused by pneumococcus in most cases, usually alone
4. Structure of lung uninvolved
5. Onset sudden
6. Course usually typical with resolution by crisis or lysis within ten days
7. Relapses or second attacks rare
8. Except for empyema, sequelae are rare
9. Prognosis good except in small infants

#### *Interstitial Bronchopneumonia*

1. Practically always secondary
2. Subjects often debilitated by other disease
3. Streptococci, staphylococci, B. influenza, or pneumococci; often mixed infections
4. Structure of lung involved
5. Onset gradual; may be insidious
6. No typical course; may be prolonged
7. Both are frequent
8. Sequelae more frequent; empyema, chronic interstitial pneumonia, etc.
9. Prognosis always serious

**Etiology.**—Age has an important influence on the incidence of interstitial bronchopneumonia. Pertussis is the most important of the primary diseases, except during epidemics of influenza, and is often followed by pneumonia in the first and second years but infrequently after that time. Pneumonia secondary to measles is much more common in young children (those of one to three years) than in those who are older. Pneumonia following diphtheria is found almost exclusively in those children with diphtheria of the larynx upon whom intubation or tracheotomy has been performed. These operations are required more frequently in the second and third years than at all other ages combined. It therefore follows that interstitial bronchopneumonia is met with often in the first three years and with rapidly diminishing frequency thereafter.

Interstitial bronchopneumonia complicates measles, pertussis, diphtheria and epidemic influenza with great frequency and more rarely varicella, scarlet fever, erysipelas and other infections. Owing to the ease of transmission it is a great cause of the mortality in orphanages and foundling asylums. Direct contact



plays a part that cannot be denied. We have seen pneumonia spread from one patient to another in succession down the side of a ward in an institutional epidemic of measles.

Local lesions in the throat produce bronchopneumonia by aspiration of septic organisms. Thus pneumonia is not rare following streptococcus laryngitis of infancy or retropharyngeal abscess. The aspiration of particles of food or of a foreign body may determine interstitial pneumonia.

The organisms responsible for this form of pneumonia are chiefly hemolytic streptococci, Pfeiffer's bacilli (influenza bacilli) and staphylococci, but these are associated almost always with other bacteria: pneumococci, diphtheria bacilli, gram-negative cocci, etc. In determining the relative importance of the different organisms recognized by culture, sections of the lungs stained for bacteria are of paramount importance. In cases complicating measles, influenza or pertussis, it is possible that the interstitial inflammation is due in part to the primary disease.

**Pathology.**—Both lungs are affected in the great majority of instances. The lower lobes posteriorly suffer most severely, though the lesions may be uniformly distributed throughout the whole extent of both lungs. Occasionally it happens that the same lung or different lungs may be the seat of quite distinct processes as the result of the presence of different organisms. Interstitial bronchopneumonia may be found in one lung or lobe, and lobar or lobular pneumonia in another.

The gross appearance of lungs which are the seat of interstitial bronchopneumonia may differ greatly. The lungs may be greatly congested and the cut surface drip blood, or they may only show small, firm, generally yellowish areas 3 to 5 millimeters in diameter, which project from the cut surface. The surface of the lung is usually mottled bluish red and gray, the former due to areas of atelectasis found chiefly in the lower and posterior portions of the lungs. In front the lung is often emphysematous. The whole pulmonary tissue may be more or less edematous. Small, firm areas can be felt scattered throughout. Pleurisy is usually not conspicuous except when the predominant organism is the hemolytic streptococcus. If such is the case extensive collections of pus may be found in the pleural cavity. Often this pus is very thin. Interstitial bronchopneumonia is essentially a bronchiolitis and a peribronchiolitis with involvement of the alveoli that surround and lead from the bronchioles. On cross section one finds that pus exudes from the larger bronchi and that the gray firm areas have in their center small bronchi, the walls of which can often, even with the naked eye, be seen to be thickened and the cavity to contain pus. If the lung is cut parallel with the bronchi there may be seen small gray striae along their course. Not only are the bronchial walls thickened but the interlobular septa as well. These are prominent upon the cut surface as grayish lines slightly elevated above the rest of the pulmonary tissue.

The conspicuous feature of this form of pneumonia under the microscope consists in the intense involvement of the pulmonary structure, the bronchial and alveolar walls and the interlobular septa. The bronchial walls are greatly thickened by edema and by the presence of mononuclear cells of different types and by red cells which are found separating the connective tissue and the unstriped



muscular fibers. Polymorphonuclear cells and bacteria fill the cavity of the bronchioles. Their mucous membrane is largely destroyed. It is stripped away from the underlying submucosa in whole or in part and undermined by collections of polymorphonuclear cells. The alveoli implicated in the whole process are those that surround the affected bronchioles and those at the extremity of the bronchioles. Thus of the alveoli involved, some are part of the same respiratory system as the diseased bronchiole and some belong to quite different systems. The

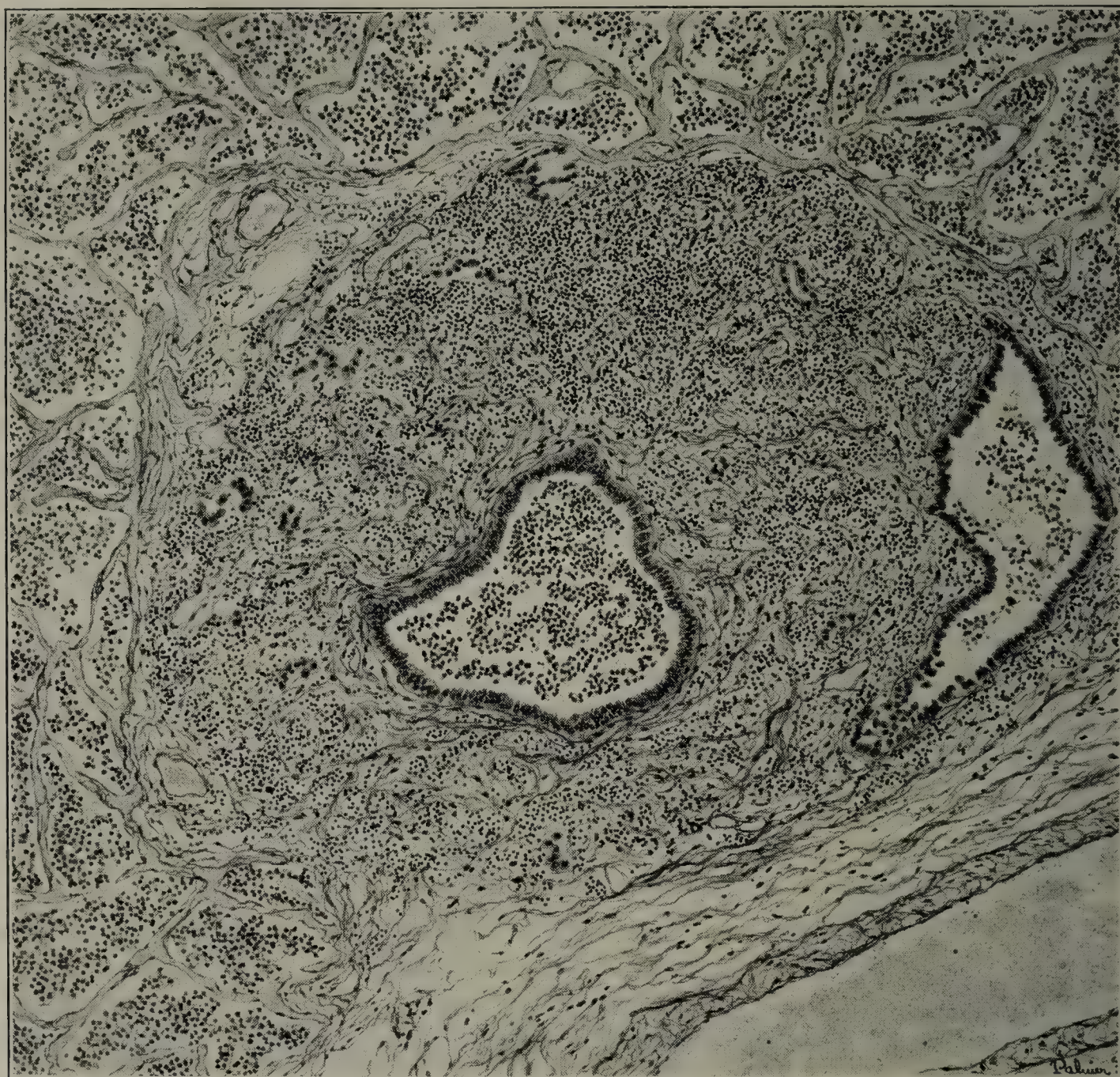


FIG. 65.—INTERSTITIAL BRONCHOPNEUMONIA WITH THICKENING OF A BRONCHUS: MICROSCOPIC APPEARANCE.

alveolar walls are thickened and infiltrated with mononuclear cells. They contain fluid and blood, fibrin, epithelial cells and mononuclear cells. The permanent, damaging character of the pathological process is seen in the early formation of connective tissue and new blood vessels which invade the walls of the bronchioles and alveoli and obliterate their cavities. The interlobular septa are thickened and invaded by cells in the same way as the alveolar walls.

Certain characteristic features are given to the anatomical process by the primary disease or by the bacteria responsible for the secondary process. If many hemolytic streptococci are present the lymphatic structures of the lung suffer severely. The lymph vessels of the bronchial walls and of the interlobular septa



are thrombosed and their cavities packed with red cells, white cells and bacteria. By the extension of this process to the surface of the lung a ready opportunity is given for the development of empyema. The pneumonia that follows epidemic influenza has some especial features. This disease apparently profoundly affects the resistance of the lung. This is shown by the remarkable alteration of the ductuli alveolares, the termination of the bronchial tree, in the early stages of complicating pneumonia. The walls of the ductuli undergo extensive hyaline degeneration, in consequence of which they become enormously dilated. This produces an extraordinary microscopical appearance; the dilatation of the ductuli may be so extreme as to give the lung a spongy appearance and texture in the gross. Rupture of the ductuli readily occurs and interstitial emphysema, pneumothorax and even extensive subcutaneous emphysema may result. Even when the alteration in the ductuli is not appreciable, the depressing effect of influenza upon the lung is sometimes to be detected. When there is an invasion with streptococci there may be a widespread necrosis of bronchial and alveolar walls with little trace of inflammatory reaction or tendency to localization. The bacillus of Pfeiffer as a secondary invader, especially if the disease has lasted more than a few days, causes small, firm, dry projecting areas of consolidation that have an appearance not unlike tubercles and doubtless have often been mistaken for them.

When interstitial bronchopneumonia has lasted three or more weeks there are firm, general pleuritic adhesions. The amount of lung involved may be very great, often nearly the whole of both lungs posteriorly. The affected lung is of a nearly uniform gray or yellowish gray color on section. On pressure pus exudes from the bronchi, the walls of which are markedly thickened and the cavities of many dilated. The part of the lung which is not consolidated may be almost white, owing to vesicular emphysema. Emphysema is one of the regular and striking features of interstitial bronchopneumonia in infancy, and is especially marked in the protracted cases. It is usually vesicular, involving the greater part of the upper lobes in front and the anterior margin of the lower lobes. Occasionally interstitial emphysema is seen, forming either large striae upon the surface of the lung, or blebs of considerable size along the anterior margin. This is especially common in the pneumonia accompanying epidemic influenza or pertussis. The bronchial glands are frequently swollen to the size of a large bean, and are of a reddish gray color. Microscopic examination shows the same changes as in the acute stage with a greater formation of new connective tissue and more extensive thickening of the bronchial and alveolar walls. In many places the infiltration with leukocytes and mononuclear cells may be so intense that the pulmonary structure is recognized with difficulty.

Gangrenous areas are not common and are seen more often in institutional children whose previous condition was very poor. Gangrene occurs as scattered areas of a grayish green color varying from one-fourth of an inch to two inches in diameter.

Abscesses of the lung are by no means uncommon. They were noted in about 7 per cent of our autopsies. They are usually minute and multiple, varying in size from one-sixth to one-half inch in diameter. Sometimes a portion of a lobe is fairly honeycombed with minute abscesses. In one case a large abscess



was found occupying the greater part of a lobe. Abscesses are often found in prolonged cases, in those of unusual severity, as shown by excessively high temperature and rapid extension of the disease, and in very delicate subjects. These abscesses usually begin as an accumulation of pus in the small bronchi, whose walls become softened and break down on account of the intensity of the inflammation. They may be superficial, but are more commonly in the interior of the lung; they contain yellow pus and sometimes broken-down lung tissue. Small abscesses cannot be recognized clinically; the large ones produce the symptoms and signs of empyema.

**Symptoms.**—The character of onset depends upon the primary disease. The pneumonia may or may not be preceded by bronchitis, the symptoms of pneumonia gradually superimposing themselves upon those of bronchitis. The onset is not usually sudden, the child not appearing very ill at first, but day by day becoming more so.

Interstitial bronchopneumonia complicates pertussis most frequently from the third to the fifth week, rarely in the first two weeks. The development is gradual following bronchitis of the larger tubes. In a small number of cases the pneumonia begins simultaneously with the invasion of measles, but generally not until the eruption appears. Instead of gradually falling to normal with the fading of the eruption, the temperature continues high. In diphtheria the majority of cases occur as a complication of diphtheritic laryngitis, although pneumonia may be found in the septic cases in which only the rhinopharynx is affected. Pneumonia after diphtheria may develop within two days from the beginning of laryngeal symptoms, and run a rapid course; or it may come as late as the second or third week or at any time when an intubation or tracheotomy tube is being worn. Without doubt many cases of pneumonia regarded as primary have been really secondary to pertussis or epidemic influenza, particularly when the latter disease is prevalent. With influenza the onset may be gradual with the onset of the primary disease, no differentiation between the two processes being possible; or, after two or three days of uncomplicated influenza, pneumonia may be ushered in by rapidly developing symptoms and great prostration. Death may even take place in a few hours after the complicating pneumonia has become apparent.

The symptoms of interstitial bronchopneumonia are distinguished from those of primary disseminated pneumonia more by their tendency to persist than by their unusual severity. The temperature may not be very high but is often of a remittent type with fluctuations of several degrees. It may reach 105° or 106° F. or may be as low as 101° F. with only occasional elevations to a higher level. Little can be learned about the severity of the disease from the temperature alone. The respirations are usually rapid. When the consolidation is extensive they are labored. Cough is distressing and may be nearly incessant. Especially in the early stages there is much secretion in the bronchi and the efforts to dislodge this are distressing and likely to provoke vomiting, especially with pertussis. Pain in the chest is uncommon unless there is extensive pleurisy or developing empyema.

The pulse is rapid and in the late stages feeble. In severe cases cyanosis is



the rule. It may be slight and only in the finger-tips or lips. When there is great consolidation the whole body may be of a dull leaden hue.

Nervous symptoms except restlessness, sleeplessness and irritability are not frequent. In fatal cases convulsions are common at the close and, with pneumonia complicating pertussis, they may form a striking feature throughout the whole course. Of 54 fatal cases with pertussis, 25 had convulsions, and in 22 these were present at the time of death.

The leukocyte count in interstitial bronchopneumonia is usually from 20,000 to 40,000. The increase is chiefly in the polymorphonuclear cells. But with the pneumonia complicating pertussis, the leukocyte count is apt to be high—50,000 to 75,000—and the small lymphocytes may be greatly in excess, forming 60 to 80 per cent of the total number of white cells, a matter of much diagnostic significance. Little of prognostic importance can be obtained from the number of white cells unless, with the continuance of the other symptoms, there is a pronounced progressive fall in the number of leukocytes. This is usually a bad sign. Positive blood cultures are often obtained; streptococci, staphylococci, pneumococci and influenza bacilli are the organisms usually cultivated.

Digestive disturbances are likely to be severe and troublesome, especially in infancy. There is an aversion to food. Vomiting is frequent. Diarrhea especially in the warm months may be severe. The stools are four to eight a day and loose. There is a tendency to distention. Loss of weight and strength is rapid. The urine is scanty, of a high color and specific gravity. A slight amount of albumin is usual but acute nephritis is rare.

A small number of cases of interstitial bronchopneumonia go on to recovery in the course of seven to fifteen days. The majority persist longer and it is the tendency to persistence and recurrence that forms perhaps the most characteristic feature of this form of pneumonia. The onset and course of the disease for the first week or two do not differ greatly from an attack of primary disseminated (lobular) pneumonia, but at the end of this time no signs of resolution occur. On the contrary, all the symptoms continue and the pulmonary signs advance, more and more of the lung being attacked. The physical signs may disappear in one portion of the lung only to recur again. Eventually a large part or all of both lower lobes posteriorly may be firmly consolidated.

The temperature in these protracted cases for the first two or three weeks is from 100° to 105° F., but after this time it is generally lower—from 100° to 102° or 103° F. The course is marked by frequent exacerbations and remissions. There are continued wasting, anemia, and steadily increasing prostration. The appetite is very poor and diarrhea frequent. The skin becomes dry and loses its elasticity. There may be edema of the feet and ankles. Bed sores may form; fine punctate hemorrhages or larger extravasations are seen over the abdomen, sometimes over the chest and extremities (*cachectic purpura*). Death takes place from slow asthenia, usually after five or six weeks, but the attack may be prolonged for eight or ten weeks. The general symptoms, the temperature and the wasting strongly suggest tuberculosis and such is the diagnosis often made.

Although the majority of cases in which the fever lasts over four weeks run the fatal course just described, such apparently hopeless cases occasionally



recover. The temperature gradually falls lower and lower, until it remains at the normal point. For some time after this, often two or three weeks, little change can be seen either in the general symptoms or in the physical signs. Gradually the appetite returns, the child is brighter and begins to take an interest in his surroundings, the cough abates, and little by little the signs in the lungs clear. The child may recover completely. Convalescence, however, is always slow, and may be interrupted by relapses, it being many months before health is fully restored. Although the signs of consolidation disappear in a few weeks, râles are apt to persist for a much longer time. Relapses and secondary attacks frequently occur. The general health may be so undermined that the child never quite regains his former vigor, yet in a surprising number of cases recovery seems to be complete. Protracted cases of a mild type are sometimes seen, and, although the temperature persists for a number of weeks, it is never high. We have seen one case following pertussis in which apparently complete recovery occurred after signs of consolidation had persisted for six months, and another in which they had persisted for over eight months. Very often the signs continue during the entire attack of pertussis.

The physical signs of interstitial bronchopneumonia do not differ essentially from those of acute disseminated primary pneumonia. In either case there are small areas of consolidation surrounded by a large area of relatively normal lung. Even when it is quite evident from the general symptoms that pneumonia is present, there may be no abnormal signs whatever. Small moist râles, localized or heard over both lower lobes posteriorly, are the most frequent and perhaps the only abnormality detected. There may be also sibilant and sonorous sounds. If the areas of consolidation reach any considerable size there is some impairment of the pulmonary resonance and frequently diminished, perhaps almost absent, breath sounds.

Before any alteration of the quality of the sounds can be detected, consolidation may be inferred from the ringing, metallic quality of the râles (consonating râles). Frank bronchial voice and breathing may not be detected until the tenth or twelfth day. They may never be heard, but in protracted cases they usually appear and over a considerable portion of one or both lower lobes. It is rare to find consolidation in an upper lobe alone but we have seen this occur, persist for several months and eventually entirely disappear. Pleuritic sounds are not common unless empyema develops.

In general it may be said that the physical signs of interstitial pneumonia develop slowly and disappear slowly. The râles vary greatly in number and situation. After being present in one area of the lung for days they may not be heard for a time and eventually return again. So, too, with consolidation, but not to the same extent. Even when the lungs are nearly clear relapses with fresh signs of pulmonary involvement are not unusual.

The x-ray is at times of assistance in detecting consolidated areas but does not enable one to distinguish between lobular pneumonia and interstitial bronchopneumonia. Tuberculosis may give an identical picture. We have been surprised to find, however, that in pneumonia even with frank signs of consolidation the shadow cast upon the plate is sometimes really insignificant, whereas tubercu-



losis is likely to give x-ray shadows more conspicuous than one would be led to expect from the physical signs.

**Prognosis.**—This is always serious. To a primary disease severe enough in itself is added a particularly virulent complication and this in a child usually under three years of age. The lowest mortality is probably seen with pneumonia complicating epidemic influenza. One whose knowledge of pneumonia is derived from observations of primary pneumonia in private practice can form but little idea of the frequency and severity of interstitial bronchopneumonia in institutions and hospitals for infectious disease. The mortality depends upon the age of the child, being highest during the first year, but including all ages, not less than 50 to 80 per cent of children in institutions die with pneumonia following pertussis, measles and diphtheria.

**Treatment.**—Prophylaxis is of great importance. In institutions and hospitals in which infectious disease is prevalent, patients should receive as much fresh air and be as widely separated as possible. All patients with pneumonia should be rigidly isolated and the nurses caring for them as well. There is no doubt that this form of pneumonia is far more contagious than primary pneumonia. Infants with pertussis should be especially protected against inclement weather and draughts. The early administration of antitoxin in diphtheria is the best preventive of laryngitis, without which pneumonia is infrequent.

The treatment of interstitial bronchopneumonia is carried out according to the principles laid down for the treatment of primary pneumonia. It is to be remembered that the disease is usually prolonged and severely drains the patient's strength. It is necessary to conserve this in every way and especially to maintain the nutrition at as high a point as possible. In protracted cases a fatal result appears to be due in many cases more to a disordered digestion and failing nutrition than to infection. For this reason the food must be carefully chosen and administered; it should not be forced at the beginning, but provided there is no vomiting or diarrhea the attempt should be made to have the child take an adequate quantity. In prolonged cases, when there is an aversion to food and weakness is so extreme as to make the child resist any attempt at feeding, it may be necessary to employ feeding by the stomach tube, small quantities of a concentrated food being used so as not to overdistend the stomach. Older and vigorous children may be treated out of doors in cold weather or in cool rooms. It is always advisable that the patient should have a maximum of fresh air and be out of doors if the weather is not too cold. Drugs have no part in the treatment of interstitial pneumonia except for the relief of special symptoms. In protracted cases, when there is great anemia we have employed transfusion with, as it has seemed, satisfactory results in numerous instances. Iron may be of advantage in convalescence but should not be employed when fever is present.



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## CHAPTER XLVIII

### SPECIAL FORMS OF PNEUMONIA

#### PLEUROPNEUMONIA

This term has been applied to primary pneumonias which exhibit fibrinous pleurisy out of proportion to the degree of consolidation. Between 5 and 10 per cent of the primary localized pneumonias fall into this category. Most of the cases have been in patients under three years of age.

The left lung is involved with somewhat greater frequency than the right. In most cases the pleura covering the entire lung is involved although the consolidation is confined to one lobe or a portion of one lobe. The visceral and parietal pleurae are coated with a layer of yellowish-green fibrin which may be a centimeter in thickness. There may be adhesions between the lung and the chest wall. Small pockets of pus are often found scattered through the exudate; sometimes a large pocket of pus is found, pleuropneumonia being in some instances a stage in the development of empyema. When the pulmonary lesion is on the left side, fibrinopurulent pericarditis is often associated.

Clinically these cases usually exhibit marked constitutional symptoms. Friction sounds may be unusually prominent in the early stage. After the fibrinous exudation is abundant the signs are often obscure and confusing. There may be no well-defined signs of consolidation, but as a rule the physical findings suggest empyema with the exception that the heart is not displaced. In the x-ray a typical pleural line can be seen, but this does not indicate definitely whether fibrin or pus is present. On exploratory puncture nothing may be obtained, or it may be noted that the needle is plugged with fibrin. Occasionally the needle may happen to strike a small pocket of pus and a few drops are withdrawn.

These cases are accompanied by a comparatively high mortality, particularly in very young children. Sometimes they go on to develop empyema, but they may undergo uneventful resolution. Convalescence, however, is always slow; relapses of the pleurisy are not infrequent, and dense adhesions are likely to remain, causing partial crippling of the lung.

#### CHRONIC INTERSTITIAL PNEUMONIA—BRONCHIECTASIS

In the ordinary primary pneumococcus pneumonia, organization rarely follows; the framework of the lung is not usually affected by the pathological process. With chronic interstitial pneumonia, however, the alveolar and interlobular septa are regularly inflamed and thickened, and some degree of permanent fibrosis is not uncommon. The infection clears up entirely in some of these cases, but in others a chronic progressive lesion develops with acute exacerbations.

The bacteriology is that of interstitial bronchopneumonia in general. The



process may affect an entire lobe or only a small portion; several areas may be present in the lung. In the affected portion a low-grade inflammation persists, with proliferation of the connective tissue framework of the alveolar and interlobular septa, the walls of the bronchi, and the pleura. As a result of this fibrosis, the alveoli may be obliterated in places, while elsewhere there are emphysematous areas. The process is usually irregularly distributed, in some regions being advanced and in others incipient.

When the process is extreme, the affected portion of the lung is converted into a yellowish-gray solid tissue through which run the bronchi, usually much dilated. Such an area consists of a gray fibrous background studded with minute yellowish flecks, composed of masses of fat-laden phagocytic cells. Dense adhesions may obliterate the overlying pleural cavity. The bronchial epithelium may be replaced by squamous epithelium, or it may be destroyed, the walls being lined by granulation tissue. In some instances single large bronchiectatic cavities form as in adults, but this picture is unusual in children, in whom there is more likely to be a diffuse dilatation of all the bronchi in the involved area, often an entire lobe. Lymph nodes draining the area are often enlarged to the size of a hazel nut. Usually at autopsy there is found recent acute pneumonia superimposed upon the chronic process.

**Symptoms.**—The clinical picture is that of a child who has had an attack of acute pneumonia, usually following some contagious disease, from which convalescence was slow. However, neither the symptoms nor the physical signs cleared up entirely. There remained a dry hard cough, perhaps a little pain in the chest or dyspnea. On examination there might be only a localized area of râles or perhaps an area of impaired resonance and diminished breathing. Each winter or several times during the course of a year, usually initiated by an attack of bronchitis, a flare-up in these symptoms may have been noted. Fresh consolidation is added to the old; there is fever and an increase in the local signs. The attack may not be very severe, but it drags on for weeks, and although partial resolution takes place there is an increased amount of permanent damage remaining.

The characteristic physical signs of chronic interstitial pneumonia are not usually present until the process has continued for many months. They may be found over part of a lobe, or over the entire lobe, or even the greater part of one lung. On inspection, there may be seen, in a well-marked case, retraction of the chest, which is especially noticeable when the disease is situated at the apex of the lung. The tactile fremitus is usually increased, but it may not be abnormal. There is marked dulness, often flatness, over the affected area, with exaggerated resonance over the rest of the lung. The area of flatness shades off gradually. The most striking thing on auscultation is the very feeble respiratory murmur; in many cases the lung is almost silent. More rarely there is marked bronchial voice and breathing. Râles and friction sounds may be absent except during an acute exacerbation of the symptoms, when they may be heard as in any attack of pneumonia. In recent cases there is no displacement of the heart; in those of long standing it may be drawn far to the affected side by contraction of the adhesions. In such cases there may be clubbing of the fingers.

When these lesions are once present complete recovery is impossible, and



there is always a tendency for them to increase rapidly or slowly, according to the child's vigor of constitution, his surroundings, and the frequency with which exacerbations occur. If the process is extensive the patient often succumbs to some intercurrent disease or to an acute attack of pneumonia; if limited in area, the process may be arrested and the patient recover, always, however, to be more or less embarrassed because of the crippling of a part of one lung. Not a small number of these children ultimately die of tuberculosis and in such cases it is always a difficult matter to decide whether tuberculosis was present from the beginning, or whether it was due to subsequent infection.

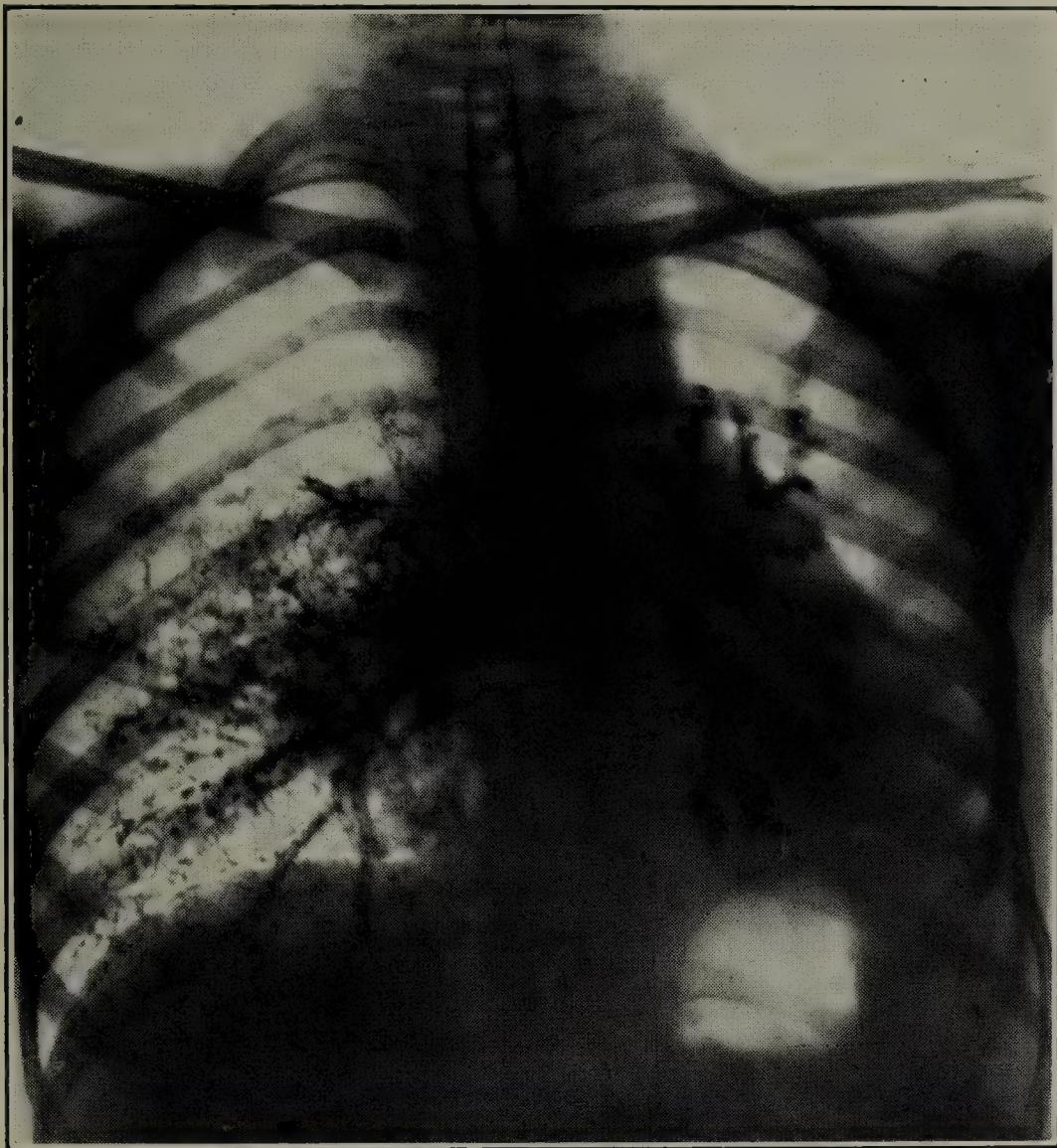


FIG. 66.—BRONCHIECTASIS.

Roentgenogram of the lungs after introduction of lipiodol, showing bronchiectasis in the left lower lobe. The right lung shows some compensatory emphysema, with normal bronchial markings.

The cases in which bronchiectasis is well developed are not common. The only characteristic additional symptom is a copious mucopurulent expectoration, which may not be fetid. It may amount to several ounces a day, and is expelled after paroxysms of coughing, which usually occur in the morning. This may continue for months, or even years, and yet these patients are generally without fever, seldom lose weight, and may have the appearance of being in fairly good health. It is rare that the physical signs of a cavity are present.

**Diagnosis.**—Foreign bodies in the lung will give symptoms of chronic pneumonia, which may be of mild or of great severity. This possibility should always be kept in mind. Many foreign bodies can be detected by the x-ray.

The most important thing is to distinguish between chronic interstitial pneu-



monia and tuberculosis. This, by symptoms and physical signs, is often impossible. Skin tests and examination for bacilli may enable one to establish the tuberculous nature of a process. There may be features in the x-ray which point strongly to tuberculosis, such as old calcified foci. The diagnosis of bronchiectasis can be confirmed by an x-ray of the chest after the introduction of lipiodol (Fig. 66).

An unusual condition that may be mistaken for chronic pneumonia and bronchiectasis in a young child is congenital cyst of the lung.

**Treatment.**—The treatment of these cases is largely symptomatic. Heliotherapy and a warm winter climate are highly desirable. Everything should be done to maintain the general nutrition at its highest point.

Cases of bronchiectasis may obtain some relief from steam inhalations. Postural drainage may be of decided benefit. The child lies with the head down for twenty minutes or more, twice a day. This allows much material to drain from the lungs assisted by coughing which is almost always induced. Further relief may be afforded by bronchoscopic drainage. In selected cases lobectomy has been successfully performed.

### LIPOID PNEUMONIA

Although various experimental studies had been made on pneumonia caused by the aspiration of lipoids, it was only in 1925 that Laughlen first described the condition in man. During the past seven years 23 cases have been observed in the pathological department of the Johns Hopkins Hospital, 14 of which were in infants under two years of age. In 2 recent instances the diagnosis was made during life.

In infants the usual cause is the instillation of mineral oil drops into the nose for an upper respiratory infection. The aspiration of vomitus may be responsible. All of the Johns Hopkins cases which occurred in older children and adults had some neurological condition favoring aspiration, such as pharyngeal paralysis, convulsions or coma. The pathological picture is characterized by the presence of mononuclear phagocytes containing fat globules (foam cells); these are found in the alveoli and in long-standing cases in the alveolar walls as well. Some lipoids are more irritating than others. In general, animal fats are the most irritating, mineral oils next and vegetable oils least. Oils containing appreciable amounts of free fatty acid are always more irritating. With a more irritating oil there may be many polymorphonuclear leukocytes in the alveoli in addition to the fat-laden phagocytes. With the more bland oils polymorphonuclear cells are not conspicuous; in addition to the mononuclear phagocytes, multinucleated giant cells may be found. In long-standing cases the alveolar walls are often thickened. Phagocytes may have transported some of the oil to the regional lymph nodes, where it may accumulate in larger aggregations. About these there is a typical foreign body reaction. A section through such a lymph node which does not transect the focus of lipoid, but only the perifocal reaction, may present a microscopic picture indistinguishable from tuberculosis.

The condition may be suspected clinically in the presence of a bilateral central consolidation which persists for a long time with little or no fever or leukocytosis.



The consolidation may be symmetrical, but is often slightly more extensive on the right side. There is no pleural involvement and the presence of tuberculosis cannot be established. A history of using oils or fats in the nose is often, but not always, obtained. In cases which have come to autopsy soon after the aspiration of lipoid, a lobular pneumonia due to pyogenic organisms is usually found in addition to the lipoid reaction, indicating that infection is carried downward with the oil.

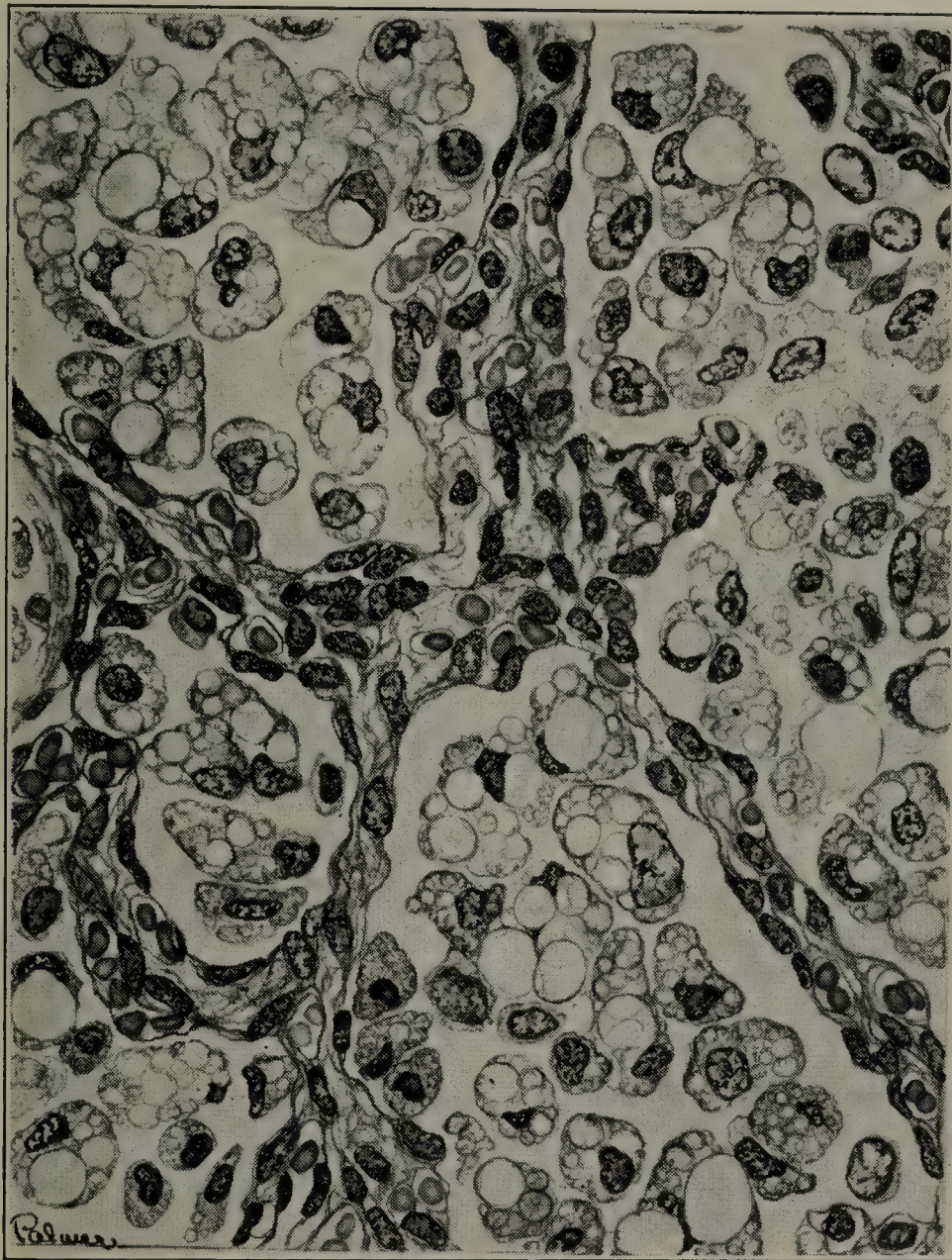


FIG. 67.—LIPOID CELL PNEUMONIA, SHOWING FOAM CELLS LADEN WITH FAT OR OIL.

Subsequently this clears up entirely and in long-standing cases only the lipoid reaction remains.

There is, as a rule, a gradual retrogression of the lesion, but it may last for months or years. The prognosis depends on the extent of involvement. Most deaths have occurred as the result of intercurrent disease.

The condition is not amenable to treatment. It occurs with sufficient frequency to make one hesitate before prescribing oil applications to the nose or throat. If these must be used, the more bland vegetable oils, such as olive or sesame oil, are to be preferred to animal fats and mineral oil.

The following case report is illustrative:

A.P. (H.L.H. 64786) was admitted to the Harriet Lane Home at the age of four months. His family history and early history were unessential. At the age of two months he developed a diarrhea that persisted in spite of many changes in the milk formula.



He also vomited a good deal and lost weight. During this illness he developed a cough and would often awake choking with mucus in his throat. For the relief of this cough he was given drops of mineral oil in the nose for several weeks. Loss of weight continued. Physical examination on admission revealed an underdeveloped, undernourished infant, breathing rapidly and coughing occasionally. There was a mild pharyngitis. The lungs showed dulness to percussion over the upper half of the right lung and some impairment in the left interscapular region. A few scattered moist râles were heard in

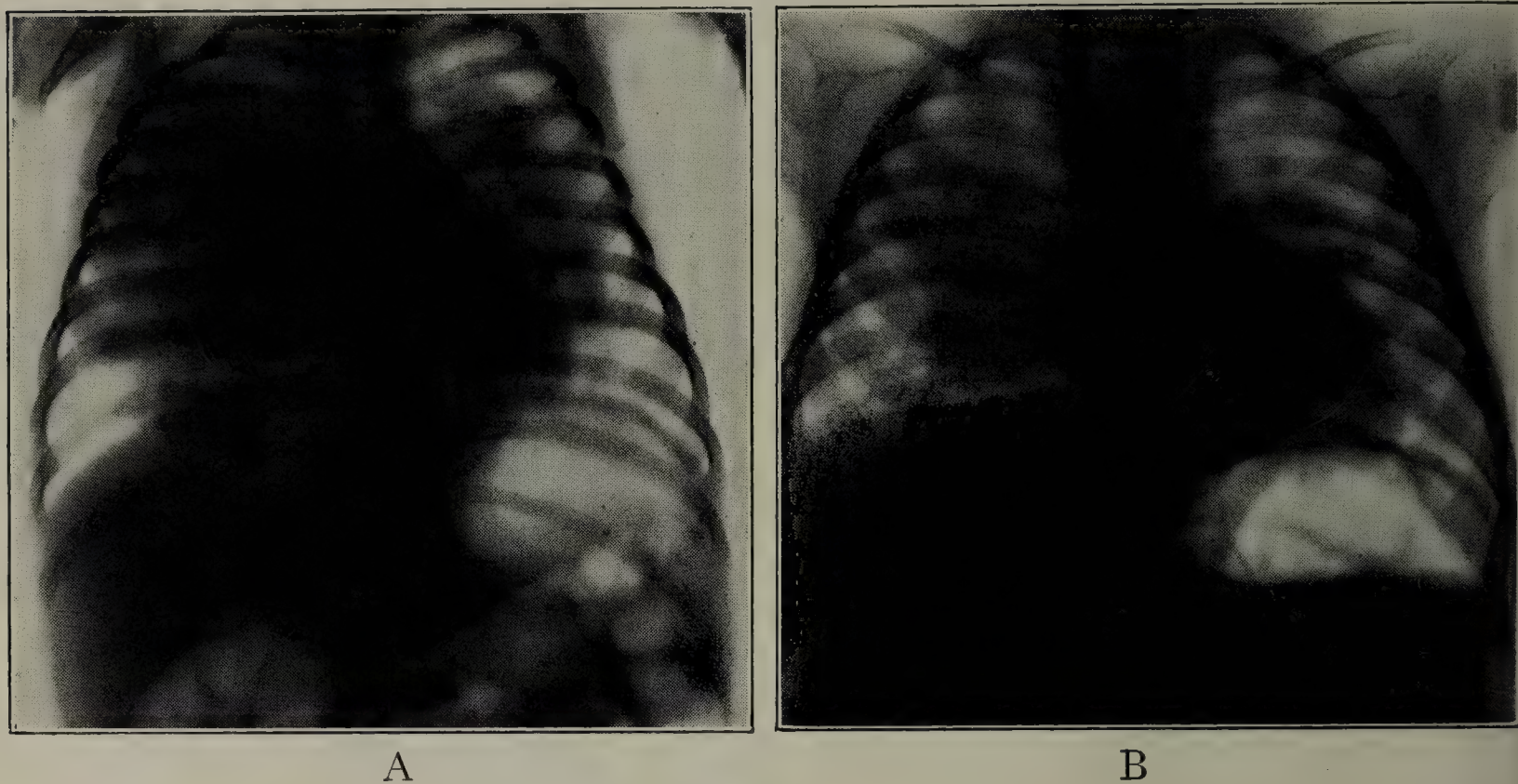


FIG. 68.—LIPOID CELL PNEUMONIA.

A, roentgen-ray appearance in a child four months of age.

B, the same patient at sixteen months of age.

these locations. The spleen was palpable. The x-ray picture is shown in the accompanying illustration.

The child was kept in the hospital for the greater part of the ensuing year. Most of this time he was completely afebrile. A moderate leukocytosis was noted (W.B.C. 13,500; P.M.N. 78 per cent) but no anemia. The signs in the lungs underwent little change. The consolidation remained in the x-ray picture, but with the growth of the chest the child seemed to grow away from it. Gain in weight was slow but steady. Suggestive clubbing of the fingers developed. Repeated attempts to demonstrate tuberculosis by skin test and stomach washings (many of which were inoculated into guinea pigs) were unsuccessful. Cultures of the sputum for fungus were negative. At the age of sixteen months (one year after he was first seen) the child developed otitis media followed by mastoiditis and a fatal streptococcus meningitis. The lungs at autopsy showed consolidations in which the typical "foam cells" were prominent; the accompanying drawing was made from them. A large part of the lipoid material extracted from the consolidated portions consisted of mineral oil.

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## CHAPTER XLIX

### PNEUMOTHORAX AND PYOPNEUMOTHORAX

#### PNEUMOTHORAX

A small collection of air in the pleural cavity following exploratory puncture is not an infrequent event. The air is rapidly absorbed and causes no disturbance. Aside from this, pneumothorax is a rare condition in young children; Owen found only 14 instances among 60,000 admissions to the Harriet Lane Home and dispensary. This did not include cases of pyopneumothorax.

Unlike the condition in adults, few cases are due to tuberculosis. Pertussis, acute pneumonia with empyema, and chronic pneumonia are more frequent causes. Tracheotomy, particularly the low operation, is sometimes followed by pneumothorax; we have seen three such instances, in all of which bilateral pneumothorax developed. Unusual causes are trauma, perforation of the chest wall from a furuncle, and foreign bodies in the lung. Two of the Harriet Lane cases followed the swallowing of lye. Sometimes cases of pneumothorax are encountered for which no explanation can be found.

It is said that pneumothorax is exceedingly rare under three years of age, but most of the cases in the Harriet Lane Home have been in small infants. The youngest was a child three weeks old in whom the symptoms suggested aspiration of a foreign body. A remarkable case of this kind is described by Zupinger in a two-year-old child who developed a complete unilateral pneumothorax during sleep. Death occurred thirty-six hours later and at autopsy a kernel of corn was found projecting from the lung into the pleural space.

The symptoms and physical signs do not differ appreciably from those in the adult. The onset is usually sudden with rapid respiration and cyanosis. When respiratory disease is already present these symptoms may be masked. There is diminished expansion of the affected side; the percussion note is usually tympanic, but sometimes there is only dulness. The breath sounds are very distant and may have an amphoric quality. The heart is often displaced toward the unaffected side. The pulse is usually rapid. The typical coin sound is often obtainable, but as a rule only in cases when the diagnosis is already apparent. Subcutaneous emphysema may be found as a complication, crepitation being obtained in the neck or elsewhere. The diagnosis of pneumothorax can of course be definitely established by x-ray or aspiration of the chest.

If the pneumothorax is causing respiratory distress the air should be removed. Sometimes the chest refills with air promptly and repeated aspirations are required. One such case was treated successfully at the Harriet Lane Home by leaving in place a needle attached to a one-way valve, which would permit expulsion but prevent readmission of air.

The mortality with pneumothorax in young children is more than 50 per



cent; death in most cases results not from the pneumothorax itself but from the associated conditions. Recovery, when it occurs, is usually complete, and rarely does the condition last more than a few days. We have, however, followed for more than eight years one child who developed a complete left pneumothorax in connection with chronic pneumonia. When last seen this patient was in excellent health and without disability, although his pneumothorax was still complete.

Artificial pneumothorax is discussed elsewhere.

## PYOPNEUMOTHORAX

During the course of treatment of an empyema, air is often introduced into the chest. Spontaneous pyopneumothorax, however, is rarely seen in early life. It occurs in a small percentage of empyemas following pneumonia; it may be found in connection with tuberculosis, but usually in older children.

The symptoms do not differ from those of pneumothorax. The characteristic signs are a succussion splash when the patient is shaken, and a horizontal line of dulness above which there is tympany. The horizontal fluid level with air above it is easily made out in roentgenograms. The treatment is discussed in connection with empyema.

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## CHAPTER L

### GANGRENE AND ABSCESS OF THE LUNG

#### GANGRENE OF THE LUNG

Pulmonary gangrene is rare in children, although probably more common than in adults. It is seldom discovered during life.

**Etiology.**—All but one of our cases have been in children under three years old, the youngest an infant of four months. Gangrene occurs for the most part in children who are ill-conditioned, feeble, or cachectic, and often follows one of the infectious diseases, particularly measles. Of twelve cases which have come under our personal observation, eight complicated interstitial bronchopneumonia. The immediate cause may be thrombosis or embolism. In other cases, particularly those associated with aspiration of foreign bodies, there is necrosis of injured lung tissue from secondary infection with putrefactive organisms. Vincent's fusospirilla and various types of anaerobes may be recovered.

**Pathology.**—The lower lobes are more frequently affected than the upper, and the surface of the lung rather than the central portions. The areas affected are of a gray or green color, usually wedge-shaped, with the base at the surface of the lung. In the early stage they are not softened, and have no gangrenous odor; later, both these conditions may be present, and masses of necrotic lung tissue may be found in a cavity with ragged walls, partly filled with fetid pus.

**Symptoms.**—There are but two distinctive symptoms of pulmonary gangrene: the fetid odor of the breath, and the expectoration of masses of necrotic lung tissue. In the cases associated with interstitial pneumonia, which include the majority of those seen, death nearly always takes place before there is any separation of the sloughs, and even before very active decomposition in the necrotic areas has occurred. Both the peculiar symptoms are therefore wanting, and the diagnosis is made only at autopsy. This has been true of nearly all the cases which have come under our observation, but these patients, with two exceptions, were infants. In older children, particularly in cases secondary to the entrance of a foreign body, the characteristic symptoms are more frequently seen, and there may be a third symptom—hemorrhage. This is present in about one-fourth of the cases and may be the cause of death. The general symptoms associated with gangrene are those of profound asthenia resembling the typhoid state.

From what has been said, it will be evident that the diagnosis is very difficult. If the characteristic odor of the breath is present, conditions in the mouth from which it might arise must be excluded. Cavity formation in tuberculosis may also be a cause of very foul breath. The tuberculin test may aid in the diagnosis. The physical signs differ in no respect from those of ordinary cases of



pneumonia. The condition is not amenable to treatment and is almost always fatal.

## ABSCESS OF THE LUNG

Multiple abscesses of the lung are not uncommon following umbilical infection of the newly born. They may occur, particularly in staphylococcus aureus infections, as a termination of interstitial pneumonia, in which connection they have already been considered. Large, single, nontuberculous abscesses of the lung are rare, obscure in their symptoms, and apt to be mistaken for localized empyema, sometimes for interstitial pneumonia with bronchiectasis. Several such cases have come under our observation: one was discovered at autopsy; others, identified by physical signs and x-ray findings, have been evacuated spontaneously during a spell of coughing or have been treated by bronchoscopic drainage or by a transpleural surgical approach. The cause of these single abscesses is usually a previous attack of acute primary pneumonia, less frequently an inflammation excited by a foreign body in the lung. The aspiration of blood or tissue during operations for tonsillectomy or adenoidectomy has been responsible for many cases.

An abscess due to a foreign body is usually accompanied by wasting and a widely fluctuating temperature of a hectic type—symptoms suggestive of a rapidly advancing tuberculous process. If the abscess follows an ordinary pneumonia the course is generally less intense. The constitutional symptoms differ little from those of empyema. There is an irregular type of fever, sometimes quite high but more often only from 99° to 101° or 102° F., a moderate cough, not much wasting, and generally not very marked prostration. A leukocytosis of 30,000 to 50,000 is usually present. The physical signs are somewhat confusing and are a combination of those present in effusion and consolidation.

There is an area of flatness shading off into dullness. The tactile fremitus may be increased or it may be diminished. The respiratory murmur is very feeble or absent over the abscess; often it is bronchovesicular in character. Friction sounds and râles are sometimes present. The heart is slightly or not at all displaced. The x-ray appearance may show a dense localized infiltration, a circumscribed cavity containing both air and fluid with a shifting fluid level, or an area of rarefaction surrounded by a circular or oval ring shadow cast by the abscess wall; in any case there may be a rapid interchange of these pictures depending on the contents of the cavity. If an exploratory needle is introduced, pus may not be found even by repeated punctures; or it may be obtained at one time and not at another, although introduced in the same intercostal space, the difference in result being due to the direction in which the needle is passed into the lung. When pus is found, the diagnosis of a localized empyema is generally regarded as established, and it is not until the chest is opened that the mistake is discovered. The operator then comes upon the lung, which may or may not be adherent. If the abscess follows acute pneumonia the pus may contain pneumococci in pure culture. If it is due to a foreign body, there is invariably a mixed infection, and the pus is apt to be fetid.

When not treated surgically, abscess of the lung may rupture into the pleural



cavity, producing a secondary empyema, or spontaneous evacuation may take place through a bronchus and recovery follow. When the cause is a foreign body, rapid recovery often follows its expulsion by coughing. If the diagnosis is made and proper surgical treatment is instituted, recovery occurs in probably the majority of cases. Whether external or internal drainage is to be preferred is a matter of judgment in each individual case.

The importance of fusospirochetal (Vincent) organisms in causing pulmonary abscesses has been emphasized particularly by D. T. Smith. He was able to recover them in 90 per cent of a series of 44 cases. Early and vigorous treatment with arsphenamin preparations in his hands yielded better results than have usually been obtained with surgical intervention alone. If possible, arsenical therapy should be commenced before extensive tissue destruction has occurred.

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## CHAPTER LI

### ACQUIRED ATELECTASIS AND EMPHYSEMA

#### ACQUIRED ATELECTASIS

Acquired atelectasis and pulmonary collapse are terms applied to a state of the lung resembling the fetal condition, but occurring in a lung which has once been expanded. It may be due to compression or to obstruction.

**Collapse from Pulmonary Compression.**—The principal cause of this form is pleuritic effusion. It may also be produced by pneumothorax, enlargement of the heart, pericardial effusion, deformities of the chest from rickets or Pott's disease, and tumors of the mediastinum or the thoracic wall. In these conditions, on account of the external pressure, the air vesicles are not filled, although the bronchi are pervious. After collapse has existed for a considerable time, changes may take place in the lung which render expansion difficult or impossible; but if there are no pleuritic adhesions, expansion often takes place readily after many weeks or even months. The symptoms and signs are those of the original disease.

Treatment is available chiefly in that form which follows pleuritic effusion, and will be considered in the chapter on Empyema.

**Collapse from Bronchial Obstruction.**—Whenever a bronchus is completely blocked, the portion of the lung to which the bronchus is distributed gradually becomes collapsed. Such obstruction may be due to the aspiration of a foreign body, to the accumulation of secretions or exudate, or to pressure outside the bronchus. If it is one of the primary bronchi which is occluded, a whole lung may be collapsed; if one of the lobar divisions, an entire lobe; if one of the smaller divisions, only a small area. The collapse does not take place immediately, but the contents of the air vesicles are gradually absorbed. The collapsed portion is slightly depressed below the surface of the lung. It is of a dark-red color, very vascular, and to the naked eye resembles a pneumonic area, which it may subsequently become.

With incomplete obstruction a different pathological picture develops. During normal inspiration there is a relaxation of the circular musculature of the bronchi, permitting enlargement of the lumen; in expiration, with contraction of these muscles, the lumen becomes narrower. In bronchitis of the smaller tubes, with swelling of the mucous membrane and the accumulation of secretions, the lumen may be wide enough to admit air during inspiration but may imprison it during the constriction that accompanies expiration. The result is distention of the alveoli—emphysema. Further narrowing of the lumen leads to occlusion during both inspiration and expiration, and focal atelectasis results. Frequently both emphysema and atelectasis are found in adjacent portions of the same lung. This occurs in many cases of pneumonia.



The development of atelectasis is favored by conditions which interfere with the mechanics of respiration—by rickets, prematurity, malnutrition, and by paralysis of the diaphragm or intercostals. It is often especially marked in the dependent part of the lung.

When the lesions are more or less equally distributed in both chests, the symptoms of acquired atelectasis are much the same as in the persistent congenital form. The respiration is rapid, and there may be inspiratory dyspnea with deep recession of the chest walls, especially if there is rickets. There is also at times cyanosis of variable intensity. The temperature is not elevated, but is frequently subnormal. The physical signs are very uncertain. There is usually feeble respiratory murmur over the affected areas, occasionally accompanied by moist râles. If the lung is expanded by a full breath a shower of fine dry râles is heard. The essential point of difference between these cases and those of congenital atelectasis is that in the former the patients are often strong at birth, crying and breathing well, giving no signs of anything wrong in the lungs until the general nutrition has suffered from some other cause. The treatment is the same as that outlined in the chapter on Congenital Atelectasis; its outcome depends mainly on the underlying condition.

The following is a fairly typical case: A female infant thirteen months old had been under observation for several months before death. During this period she suffered a great part of the time from mild bronchitis. The chest was markedly rachitic. The respiration was always accelerated, and on inspiration the lateral recession of the chest was at times extreme. There was occasionally seen slight cyanosis, and during the last few weeks it was constant. Death occurred quite suddenly. At autopsy there was found very marked vesicular emphysema of both lungs in front. Nearly the whole of both lower lobes was in a condition of collapse, and of a uniform grayish-purple color. The posterior portion of the upper lobes was similarly affected, but to a less degree. With moderate force all of the collapsed areas could be completely inflated. Bronchitis was present, but the pleura was normal.

In another group of patients the lesions are asymmetrical; often they are confined to a single lobe or to a single lung. When the condition involves a large portion of the parenchyma, compensatory expansion of the healthy lung may cause displacement of the heart and mediastinum toward the involved side (massive collapse of the lung). This may come on rapidly, over a period of but a few hours, and produce a picture of acute respiratory and circulatory embarrassment. There may be symptoms of surgical shock. A considerable proportion of such cases follow anesthesia, and it seems likely that some of them represent what in the past has been regarded as postoperative pneumonia. In others the origin is not clear. If untreated they may persist for several days or may clear up within a few hours. Prompt relief usually follows forced respiration and voluntary coughing, especially if the patient is turned on the healthy side so as to favor expansion of the involved lung. The inhalation of 7 per cent carbon dioxide in oxygen is particularly helpful as a respiratory stimulant in patients with cyanosis. Bronchoscopy and aspiration of mucus from the plugged bronchus has been recommended, but is seldom necessary.



## EMPHYSEMA

Pulmonary emphysema consists primarily in overdistention of the air vesicles. It may result in their rupture and the escape of air into the interlobular connective tissue of the lung. In infancy and childhood emphysema is usually associated with acute processes.

**Etiology.**—Cases of emphysema are divided into two groups which are due to quite different causes. In one group it is compensatory, and consists in overdistention of the air vesicles in certain parts of the lungs because the full expansion of other parts is prevented either because they are consolidated, as in pneumonia or tuberculosis, bound down by adhesions from old pleurisy, or subjected to external pressure, as from chest deformities due to Pott's disease or rickets. In these conditions it is probable that the emphysema is produced during inspiration.

In the second group of cases emphysema is produced by increased intra-alveolar pressure. The valve mechanism of the bronchial musculature in partial occlusion has just been described under Atelectasis. Emphysema accompanies expiratory dyspnea and is aggravated by severe cough. It is seen in laryngeal stenosis, in acute bronchitis and bronchopneumonia, in asthma and pertussis. It may also be produced by the artificial inflation of the lungs of the newly born.

**Pathology.**—In appearance the emphysematous lung is pale, sometimes almost white. The affected areas are prominent, and do not collapse upon opening the chest. With a lens, or even with the naked eye, the individual air vesicles can often be distinguished as minute pearly bodies, at times resembling miliary tubercles. When the force distending the air cells is only moderate, there is dilatation of the vesicles with very slight structural changes, there being usually rupture of a few alveolar septa only. The parts most affected are the upper lobes, particularly the anterior borders.

With a greater distending force rupture of many of the air vesicles results, and this may give rise to interstitial or interlobular emphysema. At times blebs are formed, varying in size from a pin's head to a cherry or even larger. These are usually seen at the anterior border or at the root of the lung on its inner surface. Again, the air finds its way between the lobules, dissecting them apart in all directions throughout the lung. Sometimes a large part of the surface of both lungs is seamed with irregular deep crevasses containing air, the largest being an inch or more in length and nearly one-fourth of an inch wide. The most severe cases occur in pertussis. On two or three occasions we have seen this form of emphysema, once to an extreme degree, when children had died from diseases unconnected with the respiratory tract, and when no history could be obtained which threw any light upon the etiology of the emphysema.

Localized emphysema not infrequently occurs in the subcutaneous tissue of the thoracic wall following exploratory punctures of the chest. This is seldom extensive and the air usually disappears in a few days by absorption without causing any symptoms. Sometimes from a rupture of an emphysematous vesicle at the hilum of the lung there occurs emphysema of the mediastinum which may spread to the tissues of the neck and ultimately to almost the entire body. This



was not uncommon in the last great epidemic of influenza. The patient gives the impression of having been artificially inflated. Such widespread emphysema is usually associated with conditions which prove fatal, the emphysema adding much to the patient's discomfort but not increasing the danger of the original disease.

**Symptoms.**—Emphysema occurring in acute pulmonary diseases gives rise to no peculiar symptoms and to no physical signs except exaggerated resonance upon percussion. This masks dulness from consolidation and also that from the liver and spleen. If the patients recover from the original disease, the emphysema greatly diminishes or disappears completely in the course of a few weeks or months. Acute interlobular emphysema cannot be detected during life, unless, as is sometimes the case, general subcutaneous emphysema is seen, which may come on quickly, last for several hours or days and then gradually disappear.

The treatment of emphysema is that of the disease with which it is associated.

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## CHAPTER LII

### PLEURISY

All the common forms of inflammation of the pleura are seen in childhood. In the great majority of cases they are secondary to disease of the lung itself. Serous effusions are much less frequent than in adults, and under three years large ones are rare. Purulent effusion (empyema) is, however, much more often seen than in adult life, and it is the most important variety of pleurisy with which the physician has to deal.

Acute pleurisy may follow inflammation of the lung so rapidly that it is not easy to determine that the lung was first affected. It occurs with lobar, lobular and interstitial bronchopneumonia, existing to some degree in nearly every case in which there is consolidation of the lung. Next in frequency to pneumonia as a cause of pleurisy are the tuberculous processes of the lung. Tuberculous pleurisy without tuberculosis of the lungs or the bronchial glands probably does not occur. Acute pleurisy is an occasional complication of the infectious diseases, particularly scarlet and typhoid fevers, measles, and influenza. In most of these cases also it is secondary to disease of the lung. Pleurisy in older children occasionally follows exposure, although it is doubtful whether this is the only cause.

The most important cause of acute pleurisy being extension from pneumonia, it follows that it is most frequent in the cold season, that it occurs more often in males than in females, and between the ages of one and five years. It may, however, be seen at all ages, and may even occur in intra-uterine life. The youngest case in which we have found extensive pleuritic adhesions as an evidence of previous inflammation was in an infant of three months. In this case firm connective-tissue adhesions were found over the whole of both lungs.

### DRY PLEURISY

This usually accompanies pneumonic or tuberculous processes in the lung. It may be a rheumatic manifestation.

**Pathology.**—On account of the frequency with which pleurisy occurs in pneumonia we have an opportunity of observing it in all stages. In the mildest cases it affects only the visceral pleura and occurs over the pneumonic areas. The pleura is injected and appears dull or roughened, due to exudation of fibrin. In more severe forms there is a thicker coating of fibrin layers, in which inflammatory cells are enmeshed. The color is gray, grayish-yellow, or yellowish-green, according as pus cells are few or numerous. In time, organization takes place from the lung outward, binding the exudate firmly. It is absorbed in part, but not always completely, there being left behind some adhesions between the visceral and parietal layers.



**Symptoms.**—There is sharp, localized pain, increased by full inspiration, sometimes tenderness on pressure, and a short, teasing cough. The pain is not always felt upon the affected side, and it may be referred to the abdomen. There may be fever and other constitutional signs. On auscultation, a pleuritic friction sound may be heard. This is usually of a dry, rubbing character, often described as leathery; at other times there are coarse, loud râles that seem close to the ear. The signs are localized, are heard both on inspiration and expiration, and are not greatly modified by coughing. Diaphragmatic pleurisy may give no localizing signs; it is often associated with shoulder or upper abdominal pain.

**Treatment.**—This should be directed mainly at the underlying condition, but the pain may require sedatives. Counterirritation is sometimes helpful. Adhesive strapping of the affected side is justified only in the tuberculous form.

### PLEURISY WITH SEROUS EFFUSION

This form of pleurisy is not very common in young children, and in infants except with acute pneumonia it is rare. In those somewhat older it is usually tuberculous in origin, in which case it frequently acts like a primary disease. It occurs as a complication of pneumonia, particularly when the hemolytic streptococcus is present, and may be seen in nephritis, rheumatic fever, scarlet fever, or any of the other acute infectious diseases.

**Pathology.**—The early changes are much the same as in dry pleurisy, but in addition there is an exudation of serum, in some cases almost from the beginning of the inflammation. This may be small in amount, or it may fill the pleural cavity. The lesions are similar to those seen in adults, except that in children there is apt to be more fibrin. The process usually terminates in absorption of the serum, but, as in dry pleurisy, more or less extensive adhesions are left behind from the fibrinous exudation. In many of the cases associated with pneumonia there is at first a clear serum, often containing pneumococci, then it becomes somewhat turbid, and finally purulent. This is especially common in infants.

**Symptoms.**—The small serous effusions which occur so frequently as a complication of pneumonia rarely cause new symptoms or any change in the physical signs except increased dulness. In the present connection only those cases will be discussed in which the amount of effusion is considerable. Pleurisy may come on with acute febrile symptoms somewhat resembling those of pneumonia, but with all the symptoms less severe, except the pain; after an illness of only two or three days the chest may be found full of fluid. Another form follows a well-defined attack of pneumonia. In a third group, usually tuberculous in origin, the disease comes on insidiously, with little or no fever, and often with no distinct pulmonary symptoms except shortness of breath. There is general weakness, sometimes loss of weight, anemia, and moderate prostration; but usually the patients are not sick enough to go to bed. The symptoms of pleurisy with effusion vary greatly. When it occurs as a complication of some acute infectious disease, it is often latent, and the diagnosis is to be made only by the physical examination of the chest.

In cases in which the fluid does not become purulent, the usual course of



the disease is for the fluid to disappear gradually by absorption, the case going on to spontaneous recovery. Serious symptoms resulting from pressure upon the heart and lungs are not common, but may occur when the fluid accumulates rapidly; hence they are most likely to be seen early in the attack. There may be great dyspnea, sometimes orthopnea, cyanosis, weak pulse, and even attacks of syncope. Death may occur with these symptoms.

The signs in the chest are essentially the same whether the fluid is serous or purulent. On inspection, there is diminished movement of the affected side, sometimes bulging of the intercostal spaces, and if the effusion is large, an increase in the measurement of the affected side of the chest. The apex beat of the heart will usually be considerably displaced if the effusion is upon the left side. It may be found in the epigastrium, at the right border of the sternum, or even in the right mammary line. In disease of the right side the displacement is less, and occurs only with a large effusion. It may then be found in or near the left anterior axillary line. On palpation, the tactile fremitus is usually absent. Percussion gives marked dulness or flatness. In a large effusion this is over the entire lung. There is also a sensation of increased resistance appreciable by the percussing finger. With a smaller effusion there is usually flatness over the lower part of the chest and dulness or tympanitic resonance above; sometimes dulness is found behind and tympanitic resonance at the apex in front. The line of flatness may change with the position of the patient. Grocco's sign is found in the majority of cases. This is a small triangular area of dulness posteriorly, with its base to the spine, on the side opposite to the effusion. The signs on auscultation are variable, and probably lead to more frequent mistakes in diagnosis than in any other pulmonary affection. Bronchial breathing and bronchial voice over the fluid are common in children. Absence of both voice and breathing is sometimes met with, but it is exceptional. The bronchial breathing over fluid usually differs from that over consolidation, in that it is feebler and distant; in some cases, however, it is indistinguishable from that heard over consolidation. Friction sounds may be heard above the level of the fluid, or when the fluid is subsiding, and there may be bronchial râles.

**Diagnosis.**—The most reliable signs for diagnosis are displacement of the heart, flatness on percussion, diminution or loss of tactile fremitus, absence of râles and friction sounds, and (usually distant) bronchial breathing. In an infant, flatness should always lead one to suspect fluid. If there is flatness over the entire lung, the existence of fluid is almost certain. Between serous and purulent effusions a positive diagnosis is possible only by the use of the exploring needle.

*Exploratory Aspiration of the Chest.*—The patient should be held in a sitting position with his back to the operator. General anesthesia is seldom required, and often contraindicated by the underlying condition. Local anesthesia is rarely of help in children under five years of age. Unless there are signs of localized fluid elsewhere, puncture is best made in the eighth interspace in the midscapular line. A 15- or 16-gauge needle, two or three inches in length and preferably with a short bevel, is used, fitted to a 10- or 20-c.c. glass syringe. Before sterilizing the equipment one should make sure that the plunger of the syringe fits snugly in the barrel and that the needle can be applied without leakage at the joint. Under strict aseptic precautions, the needle, held and directed by means of the syringe, is inserted horizontally just over the upper border



of the ninth rib. In skilled hands the change of resistance when the point pierces the parietal pleura is clearly appreciable, and deeper insertion is unnecessary. Pleural effusions under great pressure will sometimes push out the plunger, but as a rule traction is required. Enough fluid should be withdrawn to provide for appropriate study of its composition. When the exudate is inspissated and thick, it may fail to run freely into the barrel of the syringe but enough will be contained in the bore of the needle to establish an exact etiological diagnosis. When the exudate is obtained easily, one is sometimes tempted to detach the syringe, empty it, and fill it again from the needle still in place, but this should be avoided because of the opportunity it affords for the entrance of air into the pleural cavity. As long as the needle is in the chest it should be held firmly and steadily so that its point will not injure intrathoracic structures. The wound should be sponged with sterile gauze and sealed with collodion.

If no fluid is obtained, and it is desired to explore some other part of the pleural cavity, this should be done by reinsertion of a needle rather than by groping in different directions through one skin puncture. Pus may not be found because the needle is too small, too short, or because it is introduced too far into the chest.

Clear fluid, in the absence of anasarca, usually means tuberculosis. Pneumonia fluids vary from a faint turbidity to semisolid exudate; as a rule polymorphonuclear leukocytes are present in abundance, and organisms may occur in any number.

**Prognosis.**—In the acute cases complicating pneumonia, small serous effusions are usually quickly absorbed, but large ones are very apt to become purulent. Other forms of pleurisy with effusion, as a rule, terminate in recovery by absorption. In cases coming on without definite cause there should always exist a suspicion of tuberculosis, and hence every patient should be closely studied from that point of view.

**Treatment.**—This depends eventually on the underlying condition. With a large effusion causing respiratory and circulatory embarrassment from mediastinal displacement, great symptomatic relief can sometimes be obtained by its removal, even when this is merely a temporary measure.

*Therapeutic Aspiration of Pleural Fluid.*—A more complicated apparatus is required than for diagnostic puncture: one must have a device for applying continuous suction, or a three-way valve that permits the contents of the syringe to be expelled without detaching it from the needle. Under aseptic precautions the needle is inserted as described above. With young patients one may safely remove all the fluid at one sitting without fear of inducing the sort of unfavorable circulatory reaction occasionally met with in adults. The procedure should be terminated when the patient commences to cough, or if the exudate suddenly becomes blood-tinged.

## EMPHYEMA

Fully nine-tenths of the cases of empyema in children under five years either occur with or follow pneumonia, being often the sequel of the form described as pleuropneumonia. In some of these cases, however, the pleurisy masks the pneumonia, so that the former appears to be the primary disease. Tuberculosis is a rare cause in early childhood, but becomes more frequent after the seventh year. Empyema may complicate scarlet fever, measles, or any of the other acute infectious diseases. It is met with in pyemia from all causes. It may occur in the newly born as the result of infection through the umbilical wound or the



skin. It is seen with suppurative inflammations of the joints and with osteomyelitis. It may complicate suppurative processes in the abdomen, such as appendicitis or purulent peritonitis. Among the local causes may be mentioned traumatism, necrosis of a rib, and the rupture into the pleural cavity of abscesses originating in the mediastinum, in the thoracic wall, or below the diaphragm.

Since empyema is generally secondary to pneumonia, its causes are mainly those of that disease. Of 180 cases observed at the Babies' Hospital in which the nature of the infecting organism was determined it was as follows, 83 per cent of these patients being under two years of age:

TABLE XXXV  
OCCURRENCE OF VARIOUS INFECTING ORGANISMS IN 180 CASES OF EMPYEMA

Organism	Number of Cases	Per Cent
Pneumococcus .....	115	64.0
Streptococcus .....	26	14.4
Staphylococcus .....	14	7.8
B. influenzae .....	1	0.5
B. tuberculosis .....	1	0.5
Mixed infections .....	23	12.8

Pneumococci were present in two-thirds of the mixed infections.

**Pathology.**—Empyema begins very much in the manner of a dry pleurisy, but the pouring out of serum, with leukocytes and bacteria, spreads the fibrin layers apart and breaks through its meshes, forming a layer around the lung. In young patients this free fluid tends to surround the lung uniformly, responding less readily to change of posture than does empyema in the adult. With abundant exudation the lung may be compressed and the mediastinum displaced. In cases of long standing the pleura is everywhere coated with a thick layer of organizing fibrinous exudate which may seriously interfere with reëxpansion of the lung after drainage. Neglected pus may seek an outlet; the lung may be perforated and the pus evacuated through a bronchus with establishment of a broncho-pleural fistula; or external rupture may occur (empyema necessitatis), generally in the neighborhood of the nipple, sometimes below the scapula or above the clavicle; in still other cases the pus may burrow along the spine or through the diaphragm. In rare instances of long-unrecognized empyema, the pus remains localized, being completely walled off by dense layers of fibrous tissue lining the pleural cavity; the organisms may die out completely.

If the original pleuritic inflammation involved but a portion of the pleura the empyema may be sacculated. This is often seen even in infants. Interlobar empyema, without a coexisting involvement of the entire pleural cavity, in our experience is exceedingly rare. In general, empyema occurs more often on the left than on the right side, the proportion being about three to two. It is bilateral in about 3 per cent of all cases, but oftener in infants.

In streptococcus pneumonias, empyema may appear early, the fluid developing long before the pulmonary inflammation has begun to subside. With pneumococcus infections, empyema is generally more sluggish in its evolution.



**Symptoms.**—When it occurs as a sequel of pneumonia, the symptoms of empyema may follow those of the original disease without any intermission; or after the temperature has been normal or nearly so for several days it may rise again, sometimes quite suddenly, but more often gradually (Fig. 69). With this accession of fever there are other symptoms pointing to an increase in the thoracic disease. After scarlet fever or other infectious diseases, the onset of empyema is often signalized by cough, rapid breathing, and the other usual symptoms of pulmonary disease; the chest may be found full of pus by the third or fourth day. In older children empyema may come on with gradual, and even insidious symp-

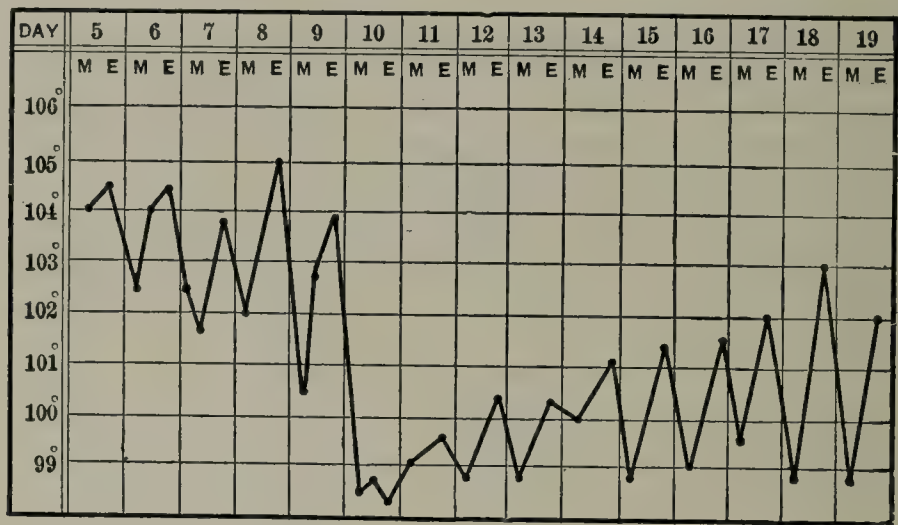


FIG. 69.—EMPYEMA FOLLOWING PNEUMONIA.

Patient two years old; single-lobe pneumonia with crisis on ninth day; gradual development of signs of empyema closely following the temperature curve.

toms, there being only slight fever, dyspnea, and cachexia. Marked leukocytosis, 25,000 to 40,000, is almost invariably present. The proportion of polymorphonuclear cells is usually from 75 to 85 per cent.

In 88 of our hospital patients with empyema, nearly all under three years old, positive blood cultures were obtained in 41 per cent. The pneumococcus was the organism usually found.

Whatever may have been the mode of onset, when the pus has been in the chest for some time the symptoms are fairly uniform. During the acute stage there are present pallor, anemia, and prostration. The respirations are generally accelerated; there may be dyspnea, but more often it is scarcely noticeable. Cough is rarely absent. The temperature is exceedingly variable; usually it ranges from 101° to 103° F. A typical hectic temperature with sweating is in our experience rare. The pulse is rapid but of fair strength. There is loss of weight; occasionally there is diarrhea. The stage of acute symptoms may last from two to four weeks. This may be succeeded by a subacute stage which may last for months. In this there is little or no fever; the patient seems convalescent so far as regaining strength and color are concerned; but cough, dyspnea, and rapid respiration continue. The chest shows no change in signs from those of the acute stage. In chronic cases the general symptoms closely resemble those of tuberculosis. There may be clubbing of the fingers, albuminuria, swelling of the feet, and often marked lateral curvature of the spine, with the concavity on the affected side.

**Diagnosis.**—The physical signs do not differ essentially from those present in serous effusion. If there are signs of considerable fluid in the chest and the



patient is under three years of age, the fluid is likely to be purulent; and also from the third to the seventh year, pus is much more often found than serum. A marked leukocytosis always makes pus more probable. Where fluid is suspected the exploring needle should be used.

The physical signs upon which most reliance is to be placed are: marked dulness or flatness on percussion, loss of tactile fremitus, feeble breathing, and displacement of the heart toward the resonant side. When in a young child these signs are present, whether general or localized, a needle should be inserted, and if pus is not found at the first trial, repeated punctures should be made until the presence or absence of fluid is definitely settled.

Empyema, while much more common, is frequently confounded with unresolved pneumonia. In the latter the dulness is usually over a single lobe, râles or friction sounds are heard, and there is no displacement of the heart; empyema may give flatness over the whole lung, or over the lower half of the chest in front and behind, râles and friction sounds are usually absent over this area, and the heart is usually displaced. The confusion of acute pneumonia or tuberculosis with empyema generally arises from placing too much reliance upon auscultation. In pleuropneumonia, with an excessive exudation of fibrin, the signs may be identical with those of empyema, except that the heart is not displaced. We have several times seen pulmonary tuberculosis, with caseation of an entire lobe, which produced signs that were nearly identical with those of a sacculated empyema. It is by the exploring needle, and by that alone, that empyema is positively differentiated from these pulmonary conditions.

There are some other thoracic diseases from which the diagnosis may be even more difficult. A large pericardial effusion gives signs which are in some cases identical with those of empyema of the left side. Marked displacement of the heart to the right is always a strong point in favor of empyema; besides, such pericardial effusions are rare in young children. A pulmonary abscess of considerable size—also a rare condition—produces signs identical with those of localized empyema, and is only distinguished from it at autopsy or operation. Abscesses from broken-down tuberculous glands may give signs resembling those of localized empyema, and like an empyema may point between the ribs in the upper part of the chest. The constitutional symptoms of empyema may at times resemble typhoid fever or malaria; but it is distinguished from them by the physical signs and by examination of the blood.

Roentgenograms may be of great assistance in diagnosis, showing the separation of the lung from the chest wall. Small effusions are difficult to distinguish by this means from an abundant fibrinous or organizing exudate.

**Prognosis.**—The outcome of a case of empyema depends chiefly upon the age and general condition of the patient, also upon the exciting cause, the duration of the symptoms, the presence or absence of serious complications, and the treatment. The mortality in young children is high; during the first year of life it is between 40 and 50 per cent. During the second year about two-thirds of the cases recover. In older children the prognosis is better; the mortality is between 10 and 15 per cent.

It is often difficult to understand why the cases in infancy do so badly; many



of these children on admission are in excellent condition and do well for a week or more after operation. Then the temperature rises, the patients lose ground rapidly and death occurs during the third or fourth week. Their inability to expand the compressed lung properly seems an important factor, as this condition is almost invariably found at autopsy. Very seldom is there trouble with drainage. Empyema in children over three years old seen reasonably early and receiving proper treatment almost invariably terminates in recovery unless the disease is double or serious complications exist. Patients with pneumococcus and

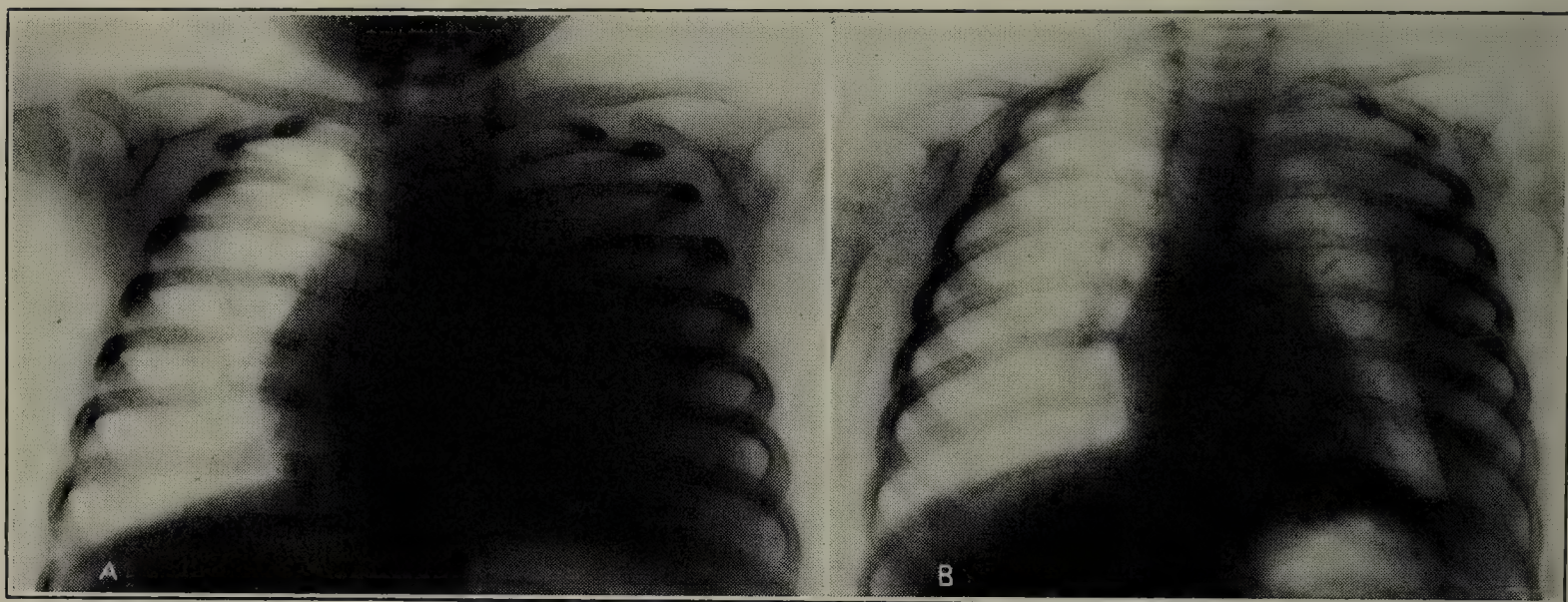


FIG. 70.—ROENTGENOGRAMS IN EMPYEMA.

Agnes C. (B.H. 259923), age nine months, had had diarrhea and intermittent fever for five days. She showed fever,  $103.6^{\circ}$  F., and considerable prostration, and there were signs of consolidation in the left upper lobe. These extended downward, tactile fremitus disappeared, dullness gave way to flatness, the râles disappeared, and bronchial breathing became more distant; the cardiac apex was pushed to the right. Meantime, the temperature had subsided and the patient became more comfortable, although x-ray (A) showed the left pleural cavity to be filled with fluid exudate. Fever reappeared, and two weeks after admission the left chest was aspirated, with removal (B) of 275 c.c. of thin, turbid, greenish-yellow fluid. Culture showed beta-hemolytic streptococci. Four days later, 220 c.c. of thick pus was aspirated; after another five days, 200 c.c. Siphon drainage was then instituted, and after a week was replaced by a short intercostal drainage tube for two or three days longer. Recovery thereafter was uneventful.

staphylococcus infections are more likely to recover than those with streptococcus or mixed infections. Great delay in operation makes the prognosis worse, because the more difficult the expansion of the lung the more prolonged is the disease. With proper early treatment these patients not only recover, but in most cases the recovery is surprisingly complete. Retraction of the chest and its resulting lateral curvature of the spine are rare, and seen only in neglected cases. In very many patients, it is impossible, after the lapse of two or three years, to detect any difference whatever in the physical signs of the two sides of the chest.

Spontaneous recovery in empyema may take place by absorption; but this is so rare that it is not to be expected. The pus may be evacuated spontaneously through a bronchus, rupture having taken place through the visceral pleura. When this occurs, a large amount of pus may be coughed up in a few hours, usually followed by immediate, but not always lasting, improvement. This is the most favorable of the natural terminations. External opening may take place, but rarely before some months; it is usually in the region of the nipple. There is an



area of redness, then a fluctuating tumor, and finally the pointing of an abscess. The discharge may continue for months, or even for years. Of 19 cases of empyema in children collected by Schmidt, in which a spontaneous discharge of pus occurred either externally or through a bronchus, there were 17 deaths and 2 recoveries. Empyema may burrow behind the diaphragm into the abdominal cavity, appearing as a psoas abscess; it may burrow posteriorly into the lumbar region; it may rupture into the esophagus, or through the diaphragm into the peritoneal cavity. All these conditions, however, are very rare. The chances of spontaneous cure in empyema are small. The statistics of empyema before the general adoption of surgical treatment are appalling.

**Treatment.**—*Aspiration*, and often repeated aspiration, is to be advised with children for temporary relief when the amount of fluid is large; also when the fever is high and the pneumonia apparently still active. It is useful also in the event of double empyema until sufficient adhesions have formed upon the first side operated upon to make opening of the other pleural cavity safe. While aspiration is a measure not solely to be relied upon, it often enables one to tide over a dangerous period and it is sometimes curative. Of 139 cases which we collected that were treated by aspiration, 25 patients were cured, 8 of these by a single aspiration; 13 patients died, and the remaining 101 were afterward subjected to other treatment. Recently McEnery and Brennemann have reported more favorable figures, with complete cure in 91 per cent from repeated aspiration alone. The results in young infants were particularly gratifying. Pyopneumothorax followed aspiration in a number of instances but had no harmful consequences.

*Closed Drainage.*—Various methods of closed drainage have been employed. The simplest, and one now rather generally employed, makes use of the siphon principle to maintain the intrapleural pressure less than atmospheric. The opening into the chest is made by a puncture incision just sufficient to admit a large soft catheter, which leads by connecting glass and rubber tubing filled with water and clamped off with hemostats to a water bottle on the floor. After insertion of the tip of the catheter into the pleural cavity, the wound is tightly strapped about the tube and some means employed to seal up the chest to exclude air. The other end of the tubing is dipped below the level of the fluid in the water bottle and the tubing unclamped. By clamping or unclamping the tubing or raising or lowering the bottle the speed of evacuation of the pus may be regulated. With large effusions it is important to allow drainage to take place rather slowly, the full traction effect of the column of fluid not being exerted continuously for the first twenty-four hours. The advantages of this method are that the mechanics of respiration are not greatly interfered with and thus with large effusions and particularly in early empyema where the underlying pneumonia is still active the shock of open drainage is avoided; the fatigue and distress of frequent dressings is avoided; and the collapsed lung is assisted to expand at a time when the overlying fibrinous exudate is more plastic than it is likely to be after organization has commenced. After a few days the method may fail as an effective method of drainage, either from leakage of air about the wound or from blocking of the tube with fibrin. In some cases no further drainage is required and the patient goes on to satisfactory recovery; in others the removal of the siphon tube



must be followed by open drainage. Siphon drainage is not applicable to cases with bronchopleural fistula.

Hart has reported favorable results with a technic that combines the advantages of negative pressure during drainage with continuous irrigation of the empyema cavity. This promotes the disintegration of fibrin masses and usually prevents clogging of the tube, so that adequate drainage may be kept up for several days without changing the apparatus. His method of applying continuous suction in cases of bronchopleural fistula has been highly successful in overcoming collapse of the lung.

*Open Drainage.*—A simple intercostal incision may be used to obtain drainage after repeated aspirations have failed to effect a cure, or after siphon drainage has become ineffectual. In young infants it is usually adequate and is preferable to rib resection. It should be delayed until closed drainage has given the lung an opportunity to expand and until sufficient adhesions have formed to prevent immediate collapse of the lung when the pleural cavity is opened to atmospheric pressure. Recent improvements in the therapy of empyema, based on this principle, have brought about a much lower mortality particularly in patients under one year of age.

In older children, especially in those over five years of age, intercostal drainage rarely proves to be adequate and a section of rib must be removed.

The usual duration of the discharge in cases treated by open drainage is from three to eight weeks. A persistence of fever or a fresh rise after operation most frequently indicates defective drainage, but it may be due to pneumonia, to abscess of the lung, to empyema of the opposite side, to pericarditis, or to some cause outside the chest. The mistake is often made of allowing the drainage tube to remain for too long a time, so that a sinus is kept open which would otherwise close.

In chronic cases, or those which have been long neglected, some further operative treatment is often necessary. The lung is so bound down by firm adhesions that further expansion is impossible, and even after the chest has receded to its utmost so that the ribs are in contact there still remains a cavity which cannot close. For such cases the only hope is an operation by which portions of several ribs are removed, thus allowing a greater collapse of the chest wall. This is known as "thoracoplasty," or "Estlander's operation." The operation is of itself a serious one, and only to be advised as a last resort in inveterate cases. Such an operation is, of course, always followed by very great deformity.

*Methods of Inducing Expansion of the Lung.*—In most of the cases, particularly the recent ones, complete expansion of the lung takes place without any difficulty, the chief agent being the cough. It may be facilitated, and the child at the same time amused, by blowing soap bubbles, or blowing a colored fluid from one bottle into another which is placed at a higher level, from which the fluid is then allowed to siphon back.



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## SECTION VIII

### *DISEASES OF THE CIRCULATORY SYSTEM\**

#### CHAPTER LIII

#### PECULIARITIES OF THE HEART AND CIRCULATION IN EARLY LIFE

**The Fetal Circulation.**—During the latter part of fetal life the circulation may be briefly described as follows: Oxygenated blood comes from the placenta through the umbilical vein. Entering the body, it divides at the under surface of the liver into two branches, the smaller one, the ductus venosus, communicating directly with the inferior vena cava, the larger branch joining the portal vein so that its blood traverses the liver and then enters the inferior vena cava through the hepatic vein. From the inferior vena cava the blood enters the right auricle, where it is mixed with the venous blood returning from the upper part of the body by the superior vena cava. A part of the blood now passes directly into the left auricle through the foramen ovale; the remainder, through the tricuspid orifice into the right ventricle. As the requirements of the pulmonary circulation are not great, only a small part of the blood is sent through the pulmonary artery to the lungs; the greater portion passes from the pulmonary artery through the ductus arteriosus into the aorta, joining here the blood from the left ventricle. The blood thus finds its way from the right heart to the left only in small part by way of the lungs, the greater part passing directly from the right auricle to the left, or from the right ventricle into the aorta through the ductus arteriosus. The blood returning to the placenta comes directly from the arterial tree, the umbilical arteries being a continuation of the hypogastric arteries. The inefficiency of such a system is obvious. The blood coming from the placenta to the fetus is somewhat less saturated with oxygen than maternal arterial blood. With the exception of the portion entering the liver by the portal vein, none of this blood is supplied to the fetal tissues until it has been diluted with the venous blood of the fetus. The blood returned to the placenta for oxygenation does not come from the tissues, but is a sample of the partly oxygenated and partly reduced blood supplied to the tissues. The difference in oxygen tension between the blood of the umbilical artery and vein is therefore much less than that between postnatal venous and arterial blood. The fetus compensates for this inefficient mechanism by a “hypertrophy of the blood,” an increase in hemoglobin and red cells. Similar compensation is seen in postnatal life in congenital heart disease.

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\* For general references for Section VIII see page 494.



**Changes in the Circulation at Birth.**—With the ligation of the umbilical cord, the circulation through the umbilical vein and arteries and the ductus venosus ceases. The umbilical vessels during the first few days of life are filled with small thrombi, which become organized. By the end of the first week, these vessels, as well as the ductus venosus, are usually closed at their extremities, although they may remain patulous throughout the greater part of their extent for several weeks. They subsequently atrophy to the condition of small fibrous cords. Closure of the ductus arteriosus and of the foramen ovale does not occur as abruptly as was formerly supposed. During the first few weeks these passages become functionally useless, but complete anatomical obliteration requires months and often

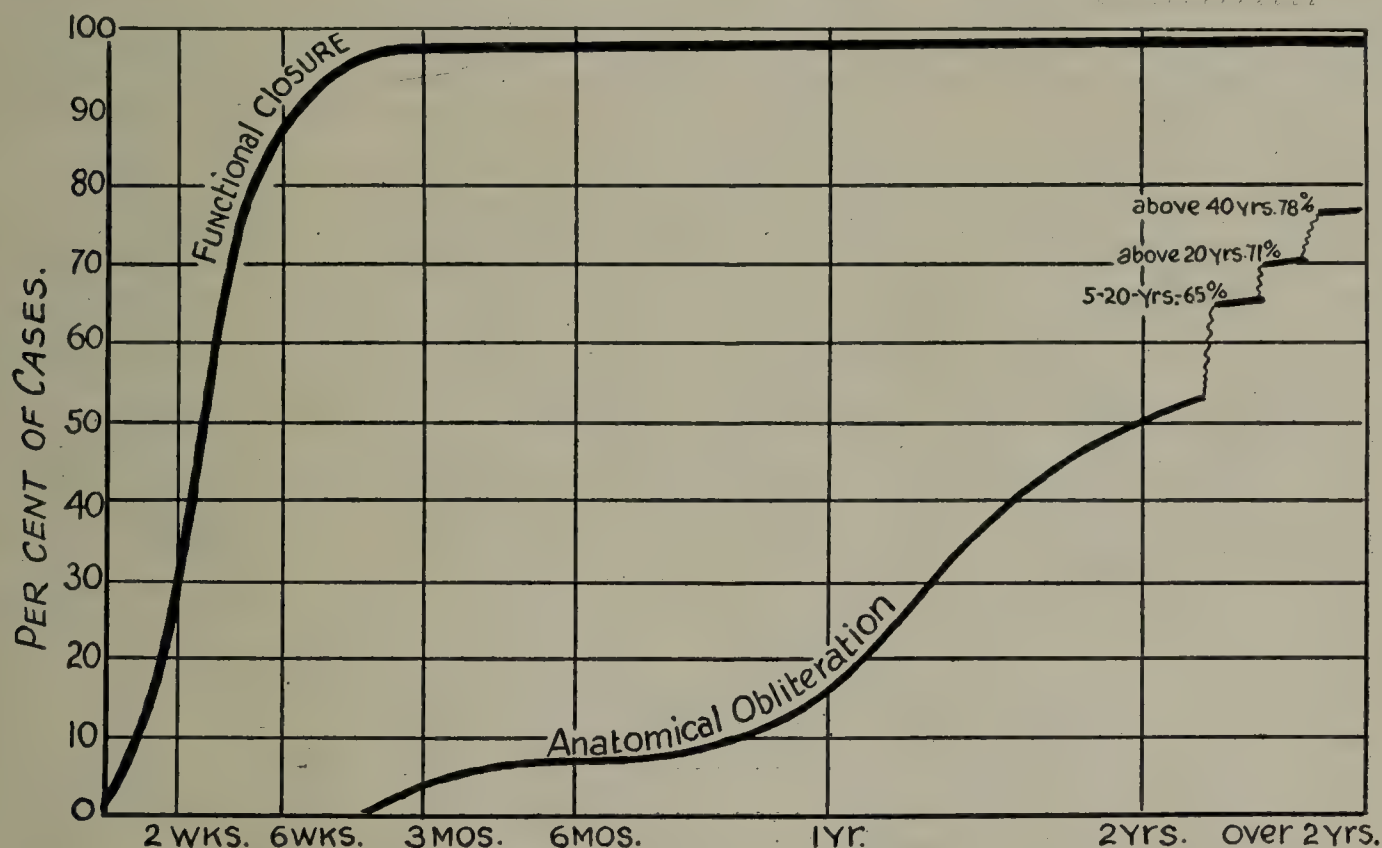


FIG. 71.—RATE OF CLOSURE OF FORAMEN OVALE (AFTER PATTEN).

years. The foramen ovale is closed by a valvula or curtain, which in fetal life swings free in the lumen of the left auricle. As the pulmonary circulation increases and more blood is returned from the lungs to the left auricle, the pressure in this chamber rises and the valvula closes the orifice, forming a septum. Fibrous union takes place subsequently, but in perhaps 20 per cent of adults some degree of “probe patency” persists (Fig. 71). Flow through the ductus ceases when the rising pressure in the systemic circulation equals that of the pulmonary artery; an obliterating endarteritis subsequently closes the vessel. According to Christie closure is complete in 88 per cent of the cases by the end of the eighth week.

**Size and Growth of the Heart.**—The weight of the heart relative to the weight of the body is slightly greater in infancy than in later life, it being smallest at about the seventh year. The average weight at the different periods of life is given in Table XXXVI.

According to Scammon, the growth of the heart is negligible during the first three or four months. The rate of growth is then similar to that of the body as a whole until the end of the first year, after which the heart grows



TABLE XXXVI\*  
WEIGHT OF HEART RELATIVE TO WEIGHT OF BODY AT DIFFERENT AGES

Age	Weight of Heart		Ratio to Body Weight
	Ounces	Grams	
Birth .....	0.8	23	1 to 144
1 year .....	1.3	37	1 to 253
2 years .....	1.9	53	1 to 227
3 years .....	2.3	65	1 to 220
7 years .....	3.0	84	1 to 270
14 years .....	5.9	168	1 to 262
Adult .....	9.6	275	1 to 248

\* The figures are taken from personal observations and from those of Sahli, Bovaird and Nicoll, Vierordt and Gundobin.

more slowly. The rate of growth is at a minimum at six years of age. The thickness of the two ventricles is nearly identical at birth; the left ventricle grows much more rapidly, however, so that at the end of the second year it is twice as thick as the right. This ratio is maintained with little change.

**The Pulse.**—The pulse in early life is not only more frequent, but it is very much more variable than in adults. The following is the average pulse rate in healthy children during sleep:

<i>Age</i>	<i>Rate per Minute</i>
6 to 12 months.....	105 to 115
2 to 6 years.....	90 to 105
7 to 10 years.....	80 to 90
11 to 14 years.....	75 to 85

The pulse is a little more frequent in females than in males, and more frequent when sitting than when lying down. Muscular exercise or excitement increases the pulse rate from twenty to fifty beats. Very trivial causes disturb not only the frequency but the force of the pulse. The pulse in young infants may be irregular even in health and during sleep. When rapid, it is frequently irregular without special significance. No dicrotism is seen in the pulse wave of early infancy.

The circulation is much more active in infancy than in later childhood; thus, according to Vierordt, the entire round of the circulation is accomplished in the newly born in twelve seconds; at three years, in fifteen seconds; in the adult, in twenty-two seconds. Blumgart and Weiss also found the circulation time in children shorter than in adults both in absolute values and in values reduced to square meter of body surface. It is a well-established clinical fact that children tolerate forms of plaster casts, splints, and suspension fixation appliances which in the adult would lead to marked circulatory embarrassment.

**Blood Pressure.**—The following table, taken from 397 observations made by Lincoln, gives normal arterial pressure values:



TABLE XXXVII

NORMAL ARTERIAL PRESSURE VALUES, IN MILLIMETERS OF MERCURY, 397 OBSERVATIONS

Age, Years	Systolic	Diastolic
3 .....	90	66
6 .....	97	69
9 .....	101	72
12 .....	103	74

Determinations made on younger individuals are likely to be somewhat elevated by crying. The pulse pressure throughout childhood has a relatively fixed value of 27 to 31 mm. Hg.

**Position of the Apex Beat.**—In the infant the heart is placed somewhat higher, and occupies a position a little nearer the horizontal than in the adult. This is partly due to the higher position of the diaphragm. The apex beat is therefore higher and farther to the left than in adult life. According to the observations of Wassilewski and Starck, whose combined examinations with reference to this point were made upon over 2100 children, the apex beat is, as a rule, outside the mammary line until the fourth year; if it is less than one-third of an inch beyond the nipple, it cannot be considered abnormal. From the fourth to the ninth year, the apex beat is in or near the mammary line. After the thirteenth year, under normal conditions, it is invariably within that line. During the first year the apex beat is usually found in the fourth intercostal space; from the first to the seventh year, it is found with about equal frequency in the fourth and the fifth spaces; after the seventh it is usually, and after the thirteenth year it is always, when normal, in the fifth space. The position of the apex beat may be considerably modified by deformities of the chest resulting from rickets, Pott’s disease, lateral curvature of the spine or intra-thoracic disease.

**Examination of the Heart.**—*Inspection.*—Bulging of the precordium is a frequent and important sign of cardiac disease during childhood. The earlier the onset of the cardiac lesion, the more marked the deformity of the chest is likely to be.

*Palpation.*—This is usually a much more satisfactory method than is inspection for determining the position of the apex beat. For this purpose the child should be in the sitting posture, with the body inclined slightly forward. Great displacement of the apex beat is always significant, and should lead one to suspect pleural effusion or adhesions; lesser degrees of displacement to the left suggest hypertrophy, especially of the left ventricle; epigastric pulsation suggests hypertrophy of the right ventricle. The heart should also be palpated for shocks, thrills and pericardial friction.

*Percussion.*—A light blow should be used, on account of the thinness and elasticity of the chest walls. In percussing the heart, changes in the percussion note are generally better appreciated if one proceeds from the lung toward the heart rather than in the opposite direction. The outline of the area of “relative” or deep cardiac dulness, especially in small children, is proportionately larger



than in the adult. This may lead to the mistaken opinion that the heart is enlarged, when it is really of normal size. The upper boundary of this area is at the second interspace or the upper border of the third costal cartilage, at the left margin of the sternum; from this point the line of dulness extends in a curved direction outward and downward, the extreme left limit being at or slightly beyond the mammary line at the fourth or fifth interspace. On the right side the line of dulness extends downward from the second to the fourth interspace in a straight or slightly curved (convex laterally) direction along the parasternal line. The lower border is indeterminable on account of the liver.

The area of "absolute" or superficial cardiac dulness, or that part of the heart uncovered by the lung, resembles in shape the same area in the adult, but it is relatively larger.

*Auscultation.*—This is of little value unless the child is quiet. The rhythm and rapidity of the child's heart action are much more easily disturbed than are the adult's, and such disturbances are consequently much less significant. The rapidity of the heart in infancy is often so great as to make it difficult to determine the exact period in the cardiac cycle at which a murmur occurs. In patients old enough to coöperate, a deep inspiration may be helpful by slowing the heart for a few cycles. In most instances the sounds can be identified by their character, the second sound being a sharp click while the first sound has in addition a dull muscular element; the first sound is usually loudest at the apex and the second sound at the base. However, these criteria may fail, particularly when the sounds are replaced by murmurs; in severe myocarditis the first sound loses its muscular quality and closely resembles the second sound (tic-tac rhythm); with advanced mitral stenosis the first sound takes on a snapping, ringing quality which often causes it to be mistaken for the second sound. The sounds may be definitely identified by their relation to the apex beat or the carotid pulsation. A light stick of wood a few inches long, fastened perpendicular to the chest wall over the apex, may be of help in some instances; the moment of most abrupt mechanical disturbance, which may be either a thrust or a retraction, corresponds to systole. Up to the fourteenth year and sometimes beyond this, the pulmonary second sound is regularly louder than the second aortic.

In consequence of the small size and the thin walls of the chest, all sounds, both normal and pathological, appear relatively louder than in the adult, and the area of diffusion is therefore much greater. Thus it is a frequent occurrence for murmurs to be heard all over the chest both in front and behind.

Reduplication of the heart sounds, in consequence of the valves of the two sides not closing exactly together, is not uncommon in children. It occurs when the heart is rapid from exertion or excitement.

In older children, especially when lying on the left side, there is often heard a sound in the early part of diastole, the so-called "third heart sound." This is only heard in the region of the apex and always follows the second sound by an interval longer than occurs in true reduplication. The sound has the character of a dull, distant thud. It is never blowing. The sound probably results from the sudden tension of the auriculoventricular valves produced by the rapid entrance of blood



into the ventricle. It should be recognized that this sound is not an abnormality. Failure to do so may cause errors in diagnosis.

*Roentgenographic Measurement.*—When the x-ray tube is six feet or more from the patient, the error in width of the heart shadow due to divergence of the rays is negligible, and such teleoroentgenograms are useful in determining the size of the heart. The most valuable measurement is the total transverse diameter of the heart, which may be compared with normal standards for age or, better yet, with the transverse diameter of the chest. The ratio of heart width to the maximum internal diameter of the chest is quite constant throughout childhood, being 0.45 to 0.50. The following table gives the average heart width at different ages:

TABLE XXXVIII  
AVERAGE HEART WIDTH AT DIFFERENT AGES

<i>In Centimeters</i>	
<i>Age, Years</i>	<i>Heart Width</i>
3 .....	8.0
6 .....	8.9
9 .....	9.5
12 .....	10.3

This method is subject to certain limitations. The outline of the heart varies in different phases of the cardiac cycle; even more striking is the effect of respiration, the transverse diameter of the heart shadow being increased with expiration. For purposes of comparison, the plate must be accurately centered and the exposure made in moderate inspiration. Satisfactory teleoroentgenographic plates are difficult to obtain in young infants.

The shape of the heart shadow may give valuable information. A wide shadow in the upper part of the mediastinum is an almost constant finding during the early weeks of life and is apparently due to the thymus gland. Later on, such a shadow is usually caused by enlarged mediastinal glands. Three curves can usually be distinguished on the left side of the heart; the upper curve being due to the aorta, the second curve being caused by the left auricle and the third or lower curve being due to left ventricle. Undue prominence of the second curve is found with a mitral lesion. (Fig. 72.)

*Electrocardiography.*—The form of the electrocardiogram in children is essentially the same as that of adults except during the first few weeks of life, when there is a tendency to right ventricular preponderance. The only difference in the interpretation of the electrocardiogram in children and adults is that the P-R interval is normally shorter in the smaller heart. Thus in children the P-R interval is usually 0.12 to 0.16 second; 0.18 may be taken as the upper limit of normal for a child of ten years or under. The presence of first degree block indicates myocardial damage; in cases of suspected rheumatic infection this is a definite sign of cardiac involvement.

The electrocardiogram is also of aid in certain congenital malformations of the heart. Situs inversus of the heart differs from other forms of dextrocardia and presents a characteristic picture. In other cases an electrocardiogram is some-



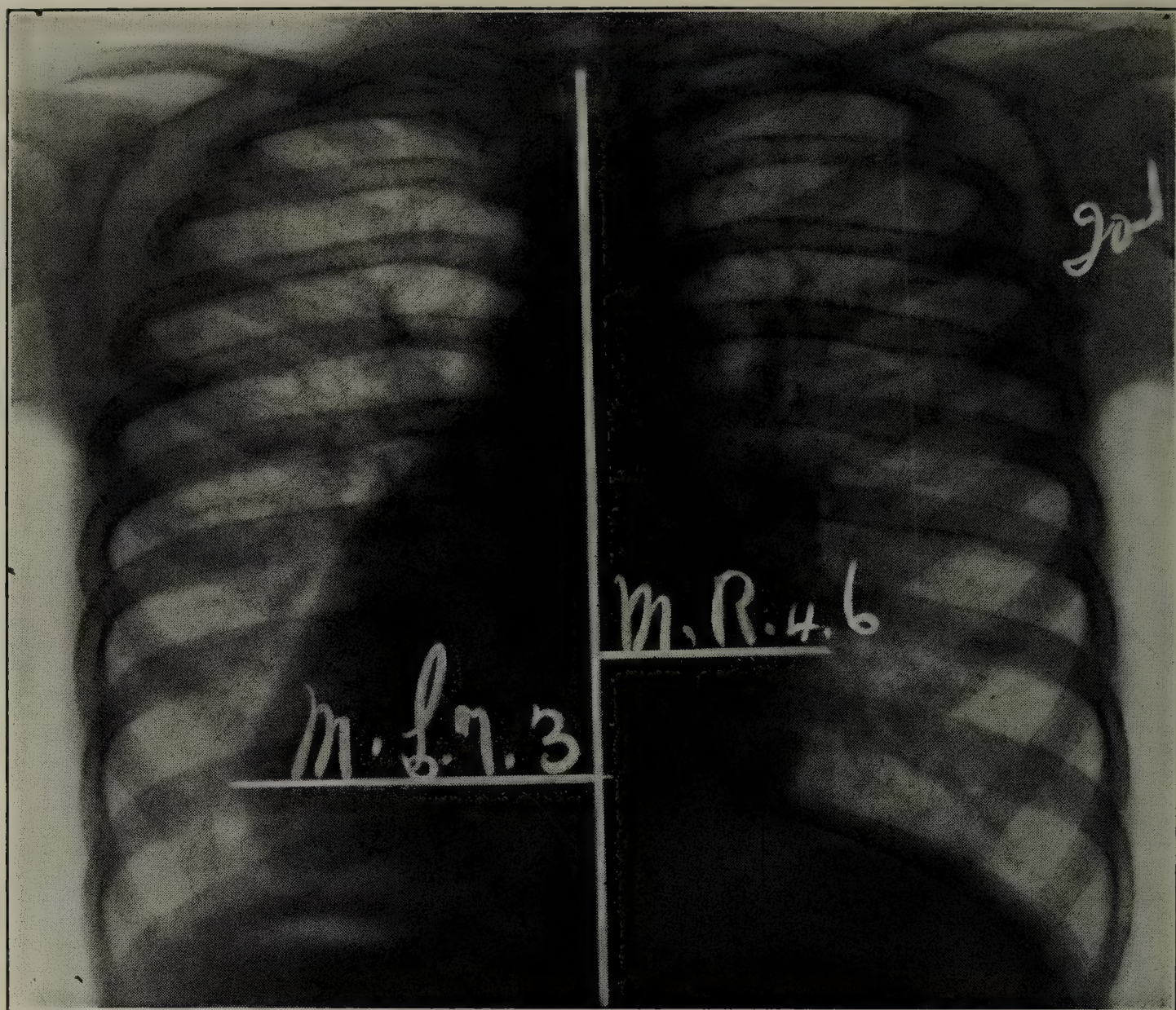


FIG. 72.—ENLARGEMENT OF THE HEART TO THE RIGHT AND LEFT.

Heart width, 11.9 centimeters; maximum internal diameter of thorax, 20.1 centimeters; cardiothoracic index, 0.59. Mitral stenosis and insufficiency. (Seen from behind.)

times helpful by indicating the relative size of the two ventricles; an abnormal QRS complex suggests some abnormality of the ventricles.

The electrocardiogram, as most other laboratory tests, is a useful adjunct. At times it is of great value, indicating definite pathology, but a normal electrocardiogram does not prove that the heart is normal.

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## CHAPTER LIV

### FUNCTIONAL DISTURBANCES OF THE HEART

#### ACCIDENTAL MURMURS

Under this term are included those murmurs that do not depend upon organic change in the heart.

In early life such murmurs are exceedingly common. Our own observations confirm those published by Hamill and others, that murmurs may be heard on careful examination in nearly 50 per cent of all children. Their existence is often a cause of much needless anxiety and of many unnecessary restrictions of a child's activities. These murmurs are almost invariably systolic in time; they are usually of moderate intensity, soft and blowing in character, and sometimes have a musical quality. Often they are not transmitted, but they may be transmitted to the axilla and even to the back as well, particularly in young children. They are unaccompanied by changes in the size of the heart or by symptoms referable to its function. They are apt to be inconstant in occurrence, and often change in character or disappear altogether by changing the posture of the child, or when the lungs are inflated.

The exact method of their production is still a matter of doubt. In certain instances they are apparently dependent upon changes in the blood occurring in anemia. In several of our patients, infants with grave anemia, quite loud murmurs have disappeared after transfusion. In other cases there can be no doubt that the murmurs are produced in the lungs, air being forced through the bronchi by the movements of the contracting heart. The term cardiopulmonary is applicable to murmurs of this origin. This murmur is not loud, is never heard to the right of the sternum and disappears when the breath is held. It is usually loudest over the base of the heart, is intensified by excitement or exertion, and often disappears on changing from a standing to a supine position.

Some murmurs are probably due to lack of tone in the cardiac muscle leading to a real but temporary insufficiency, usually at the mitral orifice. These murmurs correspond in most cases to a slight mitral regurgitant murmur. They are heard in the course of a number of acute febrile diseases—notably scarlet and typhoid fevers; also in many pale, delicate, nervous children, especially between the ages of eight and fourteen years.

Anemic murmurs are usually accompanied by a venous hum, but not by an accentuated pulmonic second sound. This venous hum is heard in the vessels of the neck and is continuous. Rarely the same sound may be heard in the first and second interspaces just to the right of the sternum.

Probably the most frequent of all accidental murmurs is a soft systolic murmur which is heard over the body of the heart, usually loudest near the left border of the sternum at about the nipple level; it is increased by placing the child on



his back and in many patients is heard only in this position. This murmur is usually intensified by overaction of the heart whether due to excitement, exertion or fever. It is accompanied by no symptoms referable to the heart or circulation and it may be met with in children who are in perfect health. This murmur is more often heard in infants and young children, but may be present for many years. It is often confused with murmurs due to cardiac malformation, but it is not loud as are they, and is heard only over a localized area.

The differentiation from murmurs due to organic cardiac disease may be difficult and only possible by continuous observation for some time. Tests of cardiac function are helpful in eliminating organic disease. Perhaps the most useful is the response of the pulse rate to exercise. The patient is allowed to hop fifty times on one foot; in the normal individual the acceleration produced by this exercise disappears within three minutes. A more prolonged tachycardia suggests organic disease, but may be due to anemia, to nervous influences, or merely to poor muscle training, as after a febrile illness.

## DISTURBANCES OF THE HEART BEAT

Disturbances of the heart's action unconnected with organic disease are quite common in children, especially from the seventh or eighth year up to puberty. Common causes are disorders of digestion, the excessive use of tea, coffee or tobacco, anemia, overpressure in schools, or other conditions leading to nervous exhaustion. The exciting cause is sometimes a great emotional disturbance such as fright or excitement, or it may follow any serious acute illness. As a rule there are more subjective symptoms with functional than with organic disease unless the latter is advanced. Functional disturbance may take the form of attacks of palpitation, tachycardia, bradycardia or arrhythmia.

The condition known in adult medicine as *irritable heart* or *effort syndrome* is frequently met with in children. There are attacks of palpitation, perhaps with dyspnea or even orthopnea; the pulse is rapid, often slightly irregular. The extremities are often cold and clammy and there is profuse general perspiration; there may be headache or vertigo. An attack is often brought on by emotional stress of any kind and may last from a few minutes to several hours.

**Tachycardia.**—Tachycardia alone occurs in certain susceptible children from slight causes. It is most frequently seen in nervous children, in conditions of anemia and when the general health is below par. We have seen numerous instances in which an acute disease such as pneumonia left the patient with a susceptibility to tachycardia lasting a year or more. Attacks are particularly common in girls about the time of puberty. The condition may persist for days or weeks at a time; it may recur for years. The pulse is often between 120 and 160 per minute, it is little affected by position, but is almost invariably lower in sleep when it may return quite to normal. The rhythm of the heart is not disturbed. The condition should not be confounded with hyperthyroidism. Treatment of such disorders should be directed toward building up the general health and to any underlying nervous condition that may be present.

**Paroxysmal Tachycardia.**—This is rare but has been observed in children as young as three months of age. There develops abruptly and without assign-



able cause an extraordinary heart rate which may be 200 to 250 per minute. Such attacks may last from a few minutes to several weeks, both beginning and ending abruptly. After an attack the pulse may for a time be abnormally slow. In prolonged cases some cardiac dilatation often occurs, and a systolic murmur may develop. Serious consequences may follow, such as swelling of the liver, dropsy, or dyspnea, but are rare. The cause and mechanism of such an abnormal cardiac stimulus are as yet obscure. Curiously, attacks may often be cut short by vomiting, voiding, or some unusual activity. Treatment is best accomplished by sedatives and complete rest. Quinidine may be tried.

**Bradycardia.**—Slow heart is a much less frequent condition than tachycardia. It is seen in a variety of pathological conditions not involving the heart, such as jaundice, typhoid fever, cerebral disease and with certain poisons. The tachycardia accompanying acute febrile diseases may be followed by a period of bradycardia which sometimes lasts for many weeks. In some children an abnormally slow pulse is an idiosyncrasy. Existing by itself, no importance is to be attached to it as a sign of cardiac disease.

Sinus bradycardia may be confused with complete heart block. A polygraph tracing or an electrocardiogram may be required to distinguish between them. Usually sinus bradycardia can be cleared up, temporarily at least, by exercise.

**Sinus Arrhythmia.**—Sinus arrhythmia is so commonly found in early life that its absence rather than its presence is to be regarded as pathological. Lincoln and Nicholson in a study of 222 normal children found it present in more than half of those aged four and in over three-quarters of the twelve-year-olds. The irregularity is caused by reflex stimuli reaching the heart by the cardiac nerves; of chief importance are impulses from the lungs which pass up the vagus nerves with each respiration. Regulation of the heart beat is apparently less perfect in children and more susceptible to outside influences.

In almost all cases, the irregularity is related to respiration; the heart usually accelerates with inspiration and slows with expiration. Rapid respiration causes the arrhythmia to disappear; with slow respiration it is more marked. It is often most pronounced during sleep and may then be associated with irregular respiration. Sinus arrhythmia can regularly be produced by deep breathing in healthy children; its absence under these conditions has been regarded as evidence of impaired cardiac function. During acute rheumatic carditis it may not be obtainable, but may reappear with convalescence. It is possible that this test indicates little more than the presence of tachycardia in rheumatic carditis; sinus irregularity disappears whenever there is tachycardia; it is seen only with a comparatively slow heart.

The recognition of sinus arrhythmia rarely offers any difficulty. Very marked cases may occasionally be mistaken for auricular fibrillation, but the relation to respiration should settle the matter.

The chief importance of sinus arrhythmia is in knowing that it is not a manifestation of cardiac disease; exercise should by no means be restricted.

**Extrasystoles.**—Extrasystoles are single, irregular beats caused by some abnormal stimulus arising within the heart, either in the auricle or ventricle. The extra beat follows closely upon the normal beat; with ventricular extrasystoles



there follows a compensatory pause, the following normal beat being omitted; in the auricular type this exact compensatory pause is not seen. The distinction between the two types can usually be made without instruments if the heart is not too rapid; it can always be made by an apex tracing or electrocardiogram, but it is usually a matter of academic interest. Extrasystoles may occur at irregular intervals or may follow each other closely. In the most marked cases, every ventricular contraction is followed by an extrasystole, causing a bigeminal pulse. Usually the extra beats are too weak to open the aortic valves; even if they do, they seldom transmit a pulse wave to the wrist; they are recognized by auscultation or palpation of the heart. If the examination is confined to the radial pulse, the occasional extrasystole cannot be distinguished from the dropped beat of partial heart block, and the bigeminal rhythm may easily be mistaken for a functional bradycardia or complete heart block.

Extrasystoles may produce no subjective symptoms; in other instances there is a feeling of precordial distress. They are more likely to occur when the pulse is slow, and may often be abolished on assuming a recumbent position, or by exercise. Under these circumstances they may well be regarded as benign.

Extrasystoles are infrequently seen in young children—more often in those over eight or ten years old. They are usually not associated with other evidences of heart disease, and under these conditions may well be ignored. In susceptible individuals this form of irregularity comes and goes from apparently slight causes—disorders of digestion, a sensitive nervous system, or convalescence from an acute febrile disease. The treatment should be addressed to the general condition, not to the heart. Exercise need not be restricted.

In advanced cardiac disease, the appearance of extrasystoles may have an unfavorable significance. Extrasystoles which accompany rheumatic manifestations should not be regarded lightly, for it is likely that they indicate irritation from an active carditis. Extrasystoles may occur as the result of overdosage with digitalis.

**Auricular Fibrillation.**—This is rarely seen in children, but has been observed as early as the fourth year. It is seen in rheumatic heart disease and indicates a played-out auricle rather than an active rheumatic process. It is an unfavorable prognostic sign. The treatment with digitalis and quinidine is discussed elsewhere.

**Auricular Flutter.**—This is practically unknown in children. Sutherland has reported three instances occurring in rheumatic heart disease. Its significance is the same as that of fibrillation.

**Heart Block.**—Partial or complete heart block occurs at times in diphtheria, in rheumatic carditis and from overdosage of digitalis. A few cases have been associated with congenital defects, notably patent interventricular septum. Complete heart block should be suspected under any of these circumstances when the pulse rate is below 60, and when the heart action is not influenced by exercise or atropine.



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## CHAPTER LV

### CONGENITAL ANOMALIES OF THE HEART

Congenital malformations of the heart are by no means uncommon. In our series of 45,000 dispensary and hospital cases the presence of some congenital abnormality was recognized in 173. It is very difficult to determine the relative frequency of the different lesions, for their clinical diagnosis during life is beset with considerable uncertainty. Moreover, the lesions that are believed to be unusual are reported in medical periodicals and those that are believed to be frequent are not recorded. An erroneous impression is thus gained from a tabulation of cases appearing in the literature.

A great variety of lesions has been described. Some of them are quite incompatible with life. The various lesions may be found alone or associated in the most complex manner. A satisfactory discussion of congenital cardiac disease would require the limits of a monograph such as that of Maude Abbott or of Vierordt. An attempt will be made in this chapter merely to present briefly the lesions that are most often encountered clinically, with a consideration of the symptoms and physical signs by which their presence can be detected.

**Etiology.**—Of the fundamental causes of congenital cardiac disease practically nothing is known. It is found with a great variety of different developmental anomalies such as incomplete development of other organs, cleft palate, transposition of viscera, encephalocele, anencephaly, or mongolian idiocy. The frequency of association is so great as to rule out mere accidental occurrence. The great majority of these malformations must be attributed to defects of embryonic development. Fetal endocarditis, once considered an important cause, will explain but a small proportion of the cases; there is complete ignorance regarding the organisms responsible for the endocarditis. Many congenital lesions are compensatory, as when a patent septum or ductus arteriosus compensates for some malformation which would otherwise be incompatible with life. Rarely a fetal condition may persist when no sufficient reason for it can be found.

We shall discuss displacement of the heart, failure of development of septa (auricular and ventricular), pulmonary stenosis and atresia, patency of the ductus arteriosus, anomalies of the great vessels, coarctation of the arch of the aorta, and idiopathic cardiac hypertrophy, and disregard the lesions at the aortic, mitral and tricuspid orifices.

**Displacement of the Heart.**—Among the rarest alterations of position are the cases of *ectopia cordis* in which the heart is situated outside of the thorax. It may be in the neck, on the surface of the chest, or in the abdominal cavity. We have seen two examples of the latter. The heart could be seen and felt in the epigastrium. When the heart is displaced to the right as the result of intrathoracic disease, the apex still points to the left; there is no change in the form of the electrocardiogram. The heart may be merely rotated so that the left ventricle is



situated anteriorly; the relation of the blood vessels and cavities is unchanged; the electrocardiogram may be normal or may show only a slight deviation of the electrical axis. Much more common in our experience is true situs inversus, in which there is a complete transposition of the other viscera as well as the heart. The liver is on the left side, the spleen on the right, etc. The whole appearance is that of a mirror picture: the caval auricle and the caval blood ventricle are on the left side, the pulmonary veins auricle and the pulmonary blood ventricle on the right; and here the electrocardiogram is characteristically altered, the P, R, and T waves usually being negative in Lead I and the customary pictures of Leads II and III reversed. This condition causes no symptoms whatever. It is usually found by accident. *Situs inversus cordis* without transposition of the other viscera is one of the rarest cardiac anomalies.

**Anomalies of Septal Development.**—Various bands and incomplete septa have been described, particularly in the auricles. Of more importance to the clinician is the failure of development of the interauricular or interventricular septum.

*Patent Foramen Ovale.*—Data in regard to functional and anatomical closure of this orifice are given on page 489. Occasionally an opening of considerable size persists for which there is no apparent explanation. A patent foramen under these circumstances is of no clinical importance and is usually not recognized during life. It gives no signs, for the pressure in the two auricles is so nearly the same that there is no appreciable passage of blood from one to the other. An open foramen ovale is recognized clinically only when there are other evidences of heart disease. It may exist as a compensatory lesion and give rise to a loud murmur. It is usually only in older patients with failing action of the heart from some other cause that *la cyanose tardive* and paradoxical embolism have been observed.

*Defects of the Interventricular Septum.*—In our experience these are the commonest of the recognizable congenital cardiac anomalies. They may exist alone or associated with other lesions. In the latter case their identity is apt to be lost in the complexity of symptoms and signs. The defect is almost always at the upper part of the septum in the so-called "undefended space." There is a failure of junction of the aortic and ventricular septa. The opening may be very small or of considerable magnitude. On account of the preponderance of power of the left over the right ventricle there is a passage of blood from left to right with each systole of the heart. This produces a harsh murmur, systolic in time, best heard immediately over the body of the heart or right ventricle. There may be a marked thrill. The heart may be slightly enlarged but usually not much so. In contrast to the loud murmur is the paucity of symptoms. Unless the defect is associated with other lesions, symptoms are usually absent. A patent septum allows blood to pass from the right to the left side of the heart in stenosis or atresia of the pulmonary artery.

In the majority of cases, septal defects produce no disturbances of conduction in the heart even though an area normally containing the main bundle of His or large branches is entirely deficient. A few examples of complete heart block have



been described with patency of the ventricular septum. We have ourselves observed one over a period of years. The child was able to exercise with no discomfort.

Complete absence or very rudimentary development of one of the septa transforms the heart into a three-chambered organ with two ventricles and one auricle or two auricles and one ventricle. There are usually other associated anomalies. Infants with such trilocular heart are usually born dead or survive a very short time. If life is maintained, cyanosis is usually a prominent clinical feature. The physical signs are not characteristic and the exact condition is difficult to recognize. The bilocular heart is even more rare.

**Pulmonary Stenosis and Atresia.**—The most striking symptoms of congenital cardiac disease—the intense cyanosis, clubbing of the fingers and the changes in the blood—are found with pulmonary stenosis and atresia. The true *morbus ceruleus* depends, in the great majority of instances, upon lesions in the right ventricle or pulmonary artery. These lesions may be in the conus arteriosus of the ventricle, at the valves themselves, or in the artery. Thickening and distortion of the valves themselves, the least frequent lesion, probably results from fetal endocarditis. The other abnormalities are developmental. Constriction of the infundibulum or its nearly complete separation from the rest of the ventricle is to be referred to an abnormal metamorphosis of the fetal structure, the bulbus cordis, which should normally be incorporated into the wall of the right ventricle. Constriction or atresia of the pulmonary artery is also developmental in origin. In order that blood can reach the lungs or the left side of the heart, associated lesions are necessary, and except in instances of mild stenosis are almost always present. These lesions are communications between the auricles and ventricles, and a patency of the ductus arteriosus. By these means a circulation, usually inadequate, may be maintained through the lungs for several months or years even with complete atresia of the pulmonary artery.

The symptoms of pulmonary stenosis are generally striking. Compensation is occasionally so nearly perfect that symptoms may be entirely absent. There are many instances on record where a high degree of stenosis has existed with nearly perfect health and the ability to undergo strenuous muscular exertion. The most conspicuous symptom is cyanosis, which may be so slight as to be appreciated with difficulty or so marked as to cause a purplish color of the skin and mucous membranes. It is exaggerated by exercise, perhaps even by the slightest exertion. The internal as well as external veins of the eyes are prominent, the conjunctivae discolored and in severe cases the gums may be purplish, spongy and bleed readily. There has been much discussion regarding the origin of the cyanosis, whether it is produced by an intermingling of venous and arterial blood or by deficient oxygenation due to interference with the passage of blood through the lungs. Both factors may play a part, but the latter is probably more important. The immediate cause of the cyanosis in either case is the same—an abnormally high content of reduced hemoglobin in the blood. When cyanosis is present, clubbing of the fingers and toes is to be expected. This clubbing consists in an enlargement of the distal phalanges especially prominent in the thumbs and great toes. The nails too are broadened with an exaggeration of the longitudinal and lateral curva-



ture. The increase in size of the phalanx generally concerns the soft tissues alone; it is infrequent for the bones to be enlarged.

In cases accompanied by cyanosis a polycythemia is regularly present. The increase in the number of red cells is roughly proportional to the cyanosis. The average number of red cells is about 7,000,000 but we have seen twice that number.

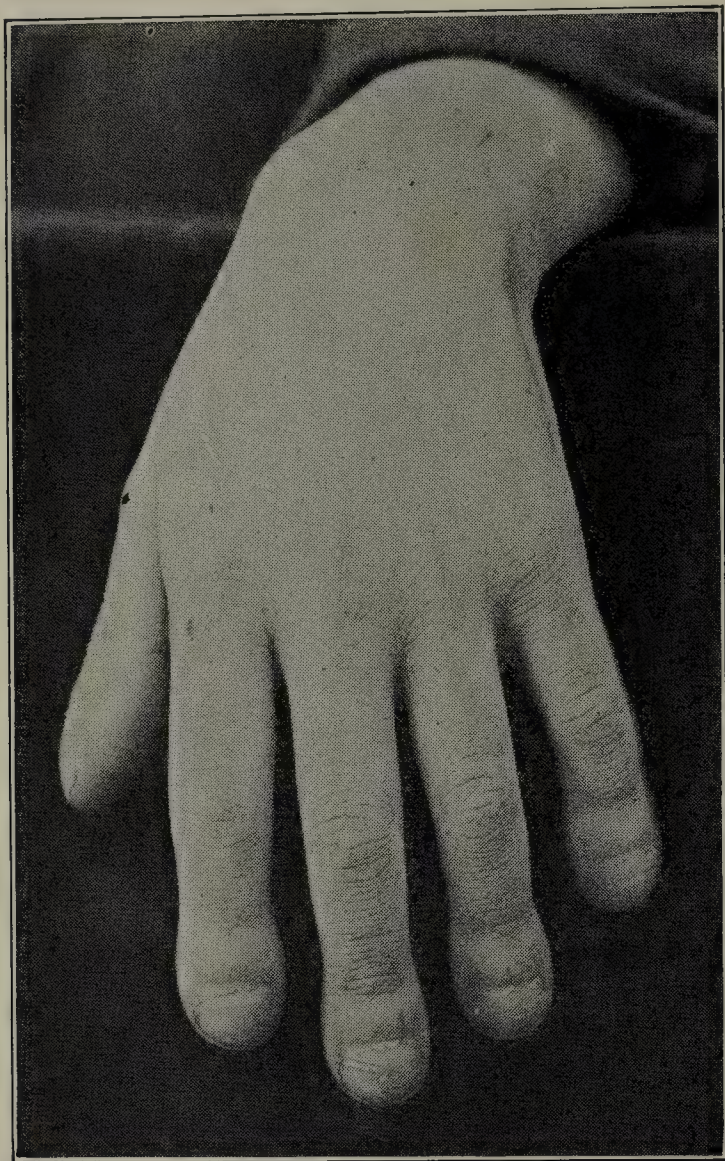


FIG. 73.—CLUBBING OF THE FINGERS IN CONGENITAL HEART DISEASE IN A BOY FIVE YEARS OLD.

The hemoglobin is very considerably increased, being regularly more than 100 per cent and often as high as 140 per cent. The number of white cells is changed very slightly, if at all.

There appears to be little change in the total blood volume, but because of the polycythemia and high hemoglobin the oxygen-carrying power of the blood is considerably increased. This may be regarded as a "hypertrophy of the blood" to compensate for the small amount that can traverse the lungs and become oxygenated.

The physical signs in pulmonary stenosis are subject to considerable variation. A nearly constant finding is a loud, harsh, systolic murmur in the second and third left interspaces, which may be transmitted laterally a short distance but not into the neck. There may also be a systolic thrill felt in the same interspaces. One would expect to find this thrill regularly but it is often absent, especially, it is said, when there is a wide opening in the interventricular septum. One would also expect that the second pulmonic sound would always be diminished or absent. This per-

haps is the rule, but at times it is even accentuated. The heart is enlarged to the right and this may be inferred from the percussion findings as well as from visible and palpable epigastric pulsations.

The associated defects<sup>1</sup> also contribute their signs, of which perhaps the most distinguishing is the murmur due to patency of the ductus. This will be described later.

**Patency of the Ductus Arteriosus.**—As a solitary lesion this is unusual but it is frequently associated with pulmonary stenosis or atresia, usually with a defect in one or both septa, or with transposition of the great vessels. It is then the chief channel by which the blood may find its way to the lungs, and without it life would be impossible. It is not a malformation but simply the persistence of

<sup>1</sup> One of the more frequent combinations of lesions in this group is the tetralogy of Fallot. This comprises (1) infundibular or pulmonic stenosis, (2) interventricular septal defect, (3) dextroposition of the aorta, with overriding of the septum, and (4) marked hypertrophy of the right ventricle.



a fetal condition, though the direction of blood flow from the aorta to the left branch of the pulmonary artery is the opposite of that which obtains in fetal life. The ductus may become very short so as to represent hardly more than an orifice. It may remain quite long and undergo dilatation.

The symptoms observed when the duct is patent depend upon the fundamental cardiac anomalies. The physical signs, however, are often entirely dominated by the persistence of the duct. The murmur by which its presence is recognized is heard best in the second and third left interspaces and is quite localized. Typically, the murmur is a continuous one with a systolic exacerbation; during diastole it may nearly disappear. It is sometimes described as a "humming top" or "machinery" murmur; it is usually harsh in character during the systolic phase. No other cardiac lesion will produce such a murmur, for the production of which there must be continuous passage of blood from one cavity to another, the pressure in the first being always higher than in the second. Unless the murmur is continuous (from published reports it apparently is not always so), the pathological condition can be suspected but not proved; with such a murmur the diagnosis is plain. No light, however, is thrown upon the associated anomalies except that they are probably such as to interfere seriously with the pulmonary circulation.

The high pressure in the aorta is transferred to a certain degree through this opening to the pulmonary artery, which undergoes some expansion with each cardiac systole. This is at times sufficient to cause a small area of dulness in the second and third left interspaces, and also to cast a shadow in the roentgenogram just above the base of the heart on the left side.

**Anomalies of the Great Vessels.**—There are numerous varieties of failure of development of the great arterial vessels. They may never have been differentiated and remain as a common trunk. The aortic septum may be formed in part only and an orifice of communication may exist between the aorta and pulmonary artery. The arterial trunks may be transposed. There are two chief varieties of transposition. In one, the so-called *corrected transposition*, the aorta is in front of the pulmonary artery but still connected with the left ventricle. This condition may cause neither symptoms nor signs. In the other or *uncorrected* type the aorta is also in front of the pulmonary artery but is connected with the right ventricle, the pulmonary artery with the left ventricle. Blood thus passes from the aorta to the systemic circulation and back to the heart again without any opportunity to give off its load of carbon dioxide and to receive oxygen. Existence is impossible unless the septa are defective.

The symptoms with uncorrected anomalies of the vessels are usually severe cyanosis and the other evidences of obstruction in the pulmonary circulation. Death generally occurs in the course of a few months. Some patients, however, have lived many years. The physical signs are difficult to interpret. Murmurs are usually present. At times none can be heard and the presence of persistent cyanosis without any murmur speaks in favor of some abnormality of the vessels. We have seen one boy with transposition of the vessels who had had symptoms for eight years and no appreciable murmur until the advent of bacterial endocarditis.

**Stenosis (Coarctation) of the Arch of the Aorta.**—This is a comparatively rare congenital lesion in which there is partial or complete occlusion of the aorta at



or near the junction with the ductus arteriosus. Coarctation may exist alone or there may be associated lesions. When the stenosis is proximal to the opening of the ductus, this channel may remain patent and the systemic circulation be carried on almost exclusively by means of the blood which passes by way of the ductus from the pulmonary artery to the aorta beyond the constriction. In such cases there is usually marked cyanosis and cardiac hypertrophy; death is likely to occur in the first few months.

When the stenosis is beyond the opening of the ductus, as is more commonly the case, a very complete collateral circulation develops, chiefly by means of the

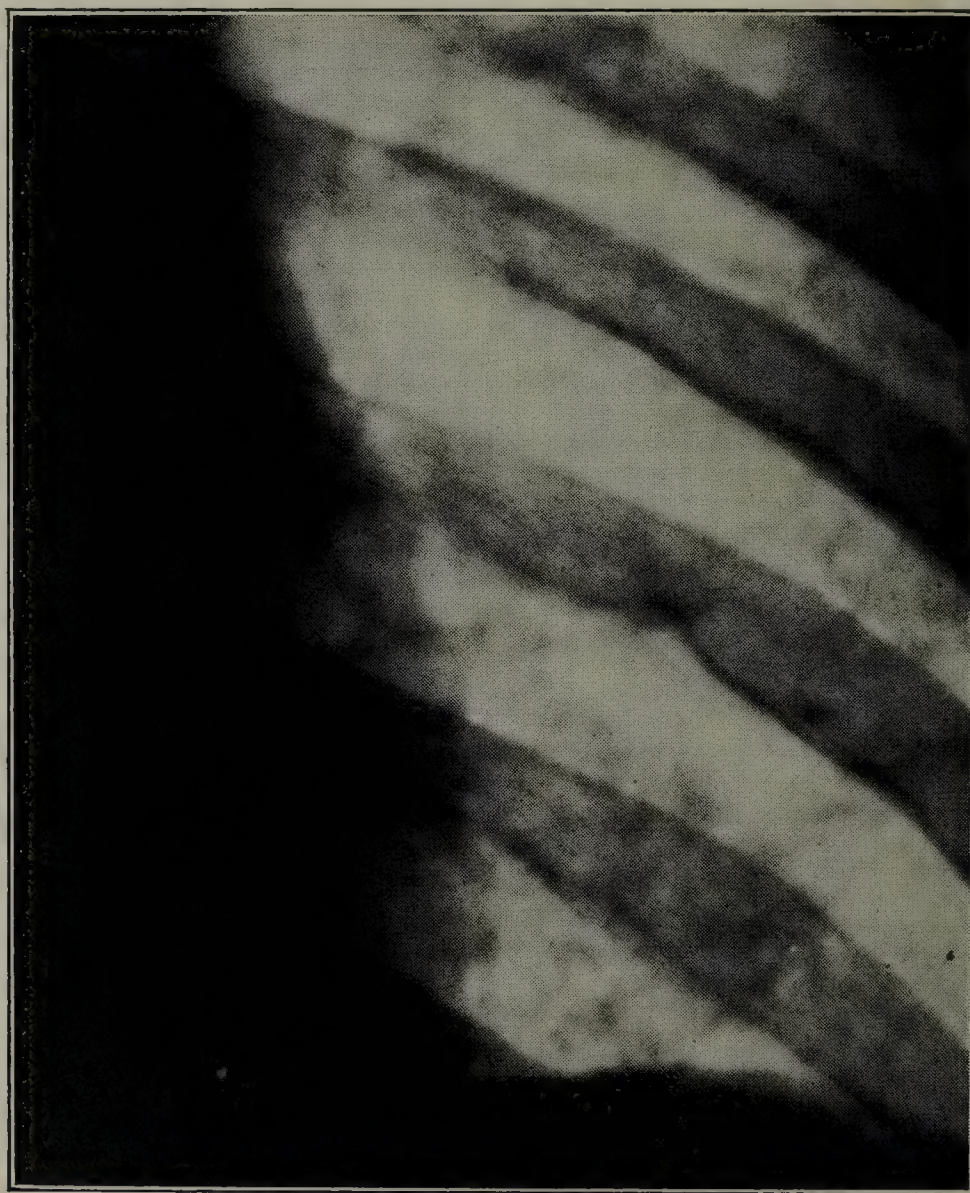


FIG. 74.—COARCTATION OF THE AORTA.

Notching of the lower margin of ribs, as seen in x-ray.

superior intercostal and mammary arteries above, and the aortic intercostal and superficial and deep epigastric arteries below. The physical signs are at times very characteristic; the condition should be recognized if the physician has it in mind. The collateral circulation may show superficially over the thorax and upper abdomen; the dorsal scapular artery may be prominent. Erosions of the ribs by the hypertrophied internal mammary and intercostal arteries may be seen by x-ray in adolescents, but seldom become evident during childhood. A marked disproportion in intensity between the radial pulse and the femoral pulse is significant; the blood pressure in the arm is higher than that in the leg. It may be impossible to feel a pulsation in the abdominal aorta or to obtain any blood pressure reading in the popliteal artery. The lower extremities may be cold; there may be pain



in the feet. There is frequently marked pulsation and a thrill in the suprasternal notch, owing to dilatation of the proximal part of the aortic arch. A high pulsation may be detected in the fluoroscope. A loud systolic murmur may be heard in the second or third spaces on the left side, well out from the sternum; sometimes it is found only in the back along the thoracic spine. In marked cases there may be signs of aortic insufficiency. When the lesion is adequately compensated for by collateral circulation, there may be no subjective symptoms; in other cases cardiac function may be inadequate. The heart may or may not be enlarged. There are many instances in which patients with this lesion have lived to an advanced age, but often they are stunted in growth, poorly nourished and complain of dyspnea. Death may occur from intercurrent disease, from circulatory failure, or sometimes from rupture of the heart or of the arch of the aorta.

**Idiopathic Cardiac Hypertrophy.**—In infants and young children there is occasionally found great cardiac hypertrophy unassociated with other conditions to which it might be secondary. There are no valvular lesions and no developmental defects have been reported, but in two of our cases clinically regarded as idiopathic coarctation of the aorta was discovered at postmortem examination. Except for the hypertrophy the musculature of the heart seems normal. Idiopathic hypertrophy is usually classed among the congenital anomalies because the hypertrophy has been found in newly born infants. Only a few cases of this kind are on record but we believe that the condition is much more common than it appears, for we have seen at least ten examples. They were in children from two and a half months to four years of age. The cause is entirely obscure. The symptoms appear in children who have seemed to be well until the onset of attacks of dyspnea and cyanosis. These attacks at first occur occasionally, but increase in frequency and severity until finally the child is constantly in the greatest respiratory distress. The temperature is not elevated and there is no leukocytosis. The heart action is rapid and tumultuous. The heart is greatly enlarged to the left. The enlargement may be detected by percussion or by means of the x-ray. The impulse may be diffuse and rippling. The lungs are clear. Death occurs as the result of circulatory failure. At autopsy the heart is found enormously increased in size. It weighs two, three, sometimes even four times as much as that of the average child of the same age.

The condition appears to be a very fatal one. No child in whom the diagnosis has been made is known to have recovered. Treatment is symptomatic. One of our cases showed distinct improvement with digitalis.

**Course of Congenital Cardiac Disease.**—A large proportion of infants with serious defects die in the first few hours or weeks after birth. Early cyanosis is a bad symptom, for it usually means marked interference with the pulmonary circulation and a condition which is not likely to improve. But there have been recorded cases where after several months the cyanosis has largely or entirely disappeared. Between conditions of practically perfect health and those of constant circulatory insufficiency there are all grades. We have seen children who eventually became capable of much physical endurance. One of our hospital patients became a prize-fighter, and another boy a member of the football and baseball teams in a large college. The patients with cyanosis and dyspnea may live for many



years but always with more or less discomfort. They remain stunted and develop secondary sexual characteristics late. Death may occur from intercurrent disease or from cardiac decompensation. There are two especially characteristic complications of congenital heart disease that terminate life—pulmonary tuberculosis and bacterial endocarditis. Pulmonary tuberculosis supervenes particularly in those

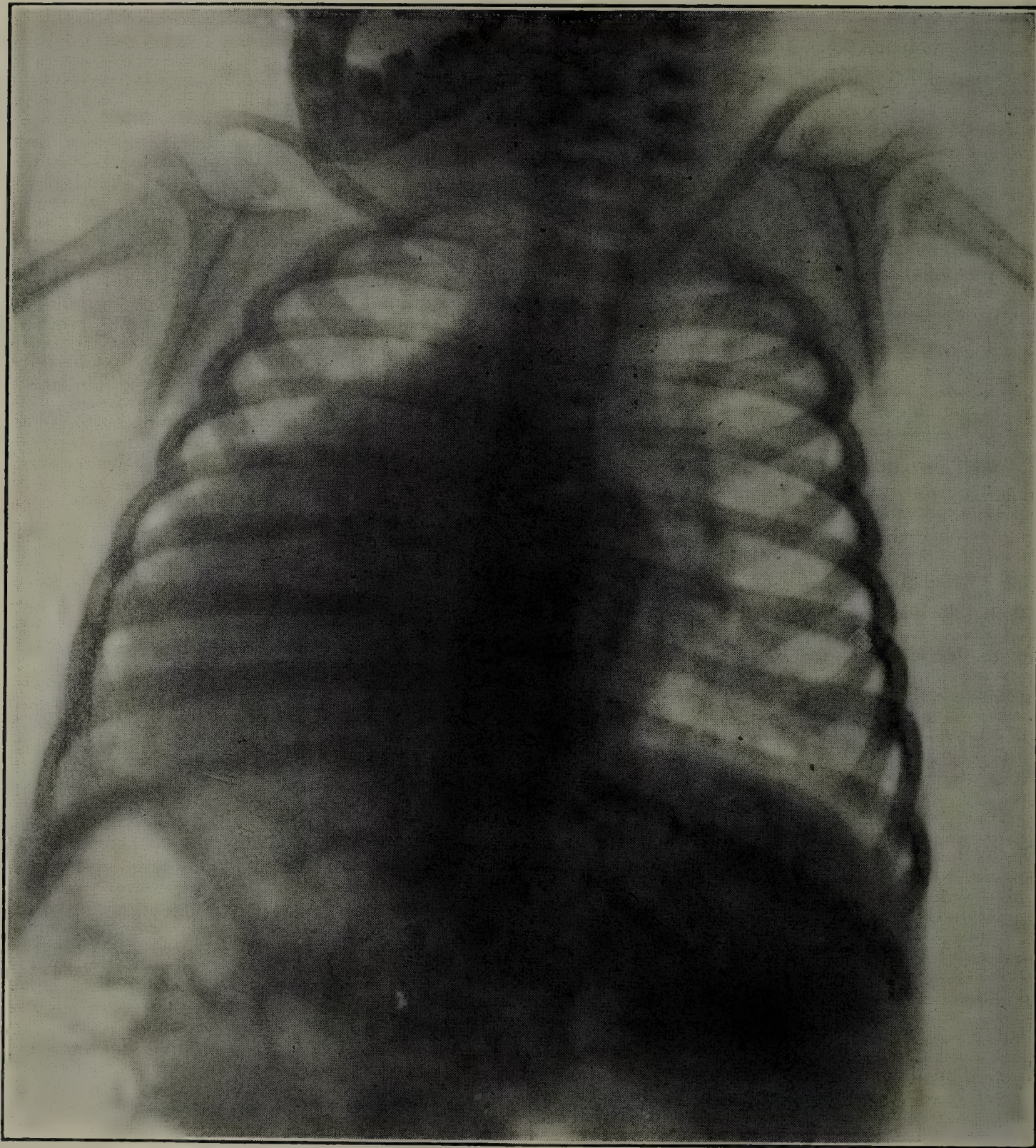


FIG. 75.—ROENTGENOGRAM OF IDIOPATHIC CARDIAC HYPERTROPHY IN INFANT TWO MONTHS OLD.  
(Seen from behind.)

patients with cyanosis, and its progress is favored by lack of a proper blood supply. This susceptibility to tuberculosis is in striking contrast to the relative freedom from tuberculosis possessed by patients with a mitral stenosis of high grade. Bacterial endocarditis, due to the *Streptococcus viridans*, is by no means uncommon; we have seen it in seven or eight patients. It pursues its usual course.

**Diagnosis of Congenital from Acquired Disease.**—Congenital disease may be suspected if the patient is under two years of age; if there is no history of



previous rheumatism; if the murmur is atypical in its location, character, or transmission; if there is a very loud murmur at the base or over the body of the heart, and if there is evidence of enlargement of the right heart. If cyanosis and clubbing of the fingers are present the diagnosis is almost certain. Rarely does the roentgen ray afford evidence one way or the other.

Especially difficult are the cases without cyanosis seen in older children. But absence of hypertrophy of the left ventricle, continued absence of rheumatic manifestations and of subjective symptoms, even with a very loud murmur, and a lesion which does not increase, all point strongly to a congenital malformation.

In patients with congenital heart disease, the symptoms of cardiac insufficiency are likely to be acute rather than chronic. Cyanosis and dyspnea may, of course, be constant, but in many cases there are acute attacks of cyanosis, dyspnea and perhaps syncope which may be very transient; we have known parents to mistake them for convulsions. The patient is often symptom-free a few hours before a fatal attack. Rheumatic carditis, on the other hand, is characterized by exacerbations of cardiac symptoms lasting for weeks and often accompanied by fever. Chronic progressive heart failure with anasarca, passive congestion of the viscera and fluid in the serous cavities is not characteristic of congenital disease.

**Diagnosis of Congenital from Accidental Murmurs.**—This is often a more difficult matter than to decide between congenital and acquired disease. From a murmur alone one should be very cautious in making a diagnosis of cardiac malformation in an infant. Accidental murmurs are systolic, usually basal, unaccompanied by enlargement of the heart, often heard in the carotids, often in the subclavian arteries, but are seldom so loud as those due to malformations.

In some instances it may be necessary to watch the progress of the case before deciding the question. Congenital murmurs are as a rule exceedingly constant. An exception to this may be made in the first few weeks of life. We have known a newly born child to exhibit a loud, rasping, continuous murmur with systolic exacerbation which had completely disappeared some weeks later. It seems reasonable to assume that this was an instance of patent ductus arteriosus and that its disappearance was due to closure of that vessel.

**Prognosis.**—This depends, of course, upon the lesions; and since their exact diagnosis during life is often difficult or even impossible, the prognosis may be exceedingly obscure. One is not warranted in forming a prognostic opinion until the child has been observed for a period of some weeks to see what may be expected.

The prognosis is best with simple lesions such as patency of the interventricular septum, but even with such severe deviations from the normal as pulmonary stenosis long life is possible if compensatory lesions are adequate.

In general the intensity of the murmur is no criterion whatever of the danger of the condition; the symptoms of circulatory insufficiency may be very severe in the absence of a murmur. The intensity of cyanosis and dyspnea show better than anything else the outlook for the future. Cases with severe polycythemia and increased viscosity of the blood usually terminate fatally at an early age, sometimes with thrombosis of the great veins or cerebral sinuses.

The possibility of superimposed pulmonary tuberculosis and of bacterial endo-



carditis must always be kept in mind; the former usually, and the latter always, runs its course uninfluenced by treatment.

**Treatment.**—This is unsatisfactory. As a rule, nothing can be done to treat patients symptomatically; in some instances digitalis may be of help. Quiet is essential in those with dyspnea. It requires nice judgment to decide regarding the ability of a child to exercise. The mistake should not be made of restraining one who is capable of living a normal life.

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## CHAPTER LVI

### DISEASES OF THE PERICARDIUM

#### ACUTE PERICARDITIS

**Incidence.**—Inflammation of the pericardium is uncommon in infancy and early childhood; it is always a more serious manifestation than in adults. In the newly born, pyemia may be responsible; up to the fourth year most of the cases complicate pneumonia and empyema, while after this rheumatic fever takes the first place as an etiological factor. Pericarditis associated with septicemia may occur at any age; any of the pyogenic organisms may be responsible. It may complicate typhoid fever, scarlet fever or tuberculosis. A fibrinous pericarditis sometimes accompanies uremia. Pericarditis may result from local causes such as trauma, ulceration of a foreign body from the esophagus into the pericardium, disease of the ribs or sternum.

An increase in the normal pericardial fluid, not to be confused with pericarditis, is often met with in severe anemias or when there is general anasarca of cardiac or renal origin. From 30 to 60 c.c. of clear serum are found in the pericardial sac, but there is no inflammation of the serous membrane. Such effusions are rarely large enough to be recognized clinically.

**Pathology.**—Rheumatic pericarditis is described elsewhere. The inflammation is a serofibrinous one, never purulent.

Pneumococcus pericarditis is always acute and resembles the inflammation of the pleura due to the same cause. In the milder cases there is seen only a fibrinous exudate; more commonly the process is severe, the layers of pericardium being covered with a thick coating of fibrin and pus. The sac may contain fluid pus, usually not more than 15 to 30 c.c., but sometimes as much as 500 c.c. When the inflammation is excited by other pyogenic organisms the lesions are similar.

Tuberculous pericarditis is rare at any age, but particularly so in early life. It may represent direct extension from caseous mediastinal nodes; usually there is widespread tuberculosis elsewhere. Proliferative or exudative lesions may predominate at the outset; in the former case the lesion is confined to a few miliary tubercles in the pericardium with a small serous or serosanguineous effusion. Acute inflammation and larger effusions are found in the latter case. The process in either case is likely to be chronic and progressive; the terminal picture is that of extensive internal and external pericardial adhesions with caseous foci.

Inflammation involving the external fibrous layer of the parietal pericardium is more properly classed as mediastinitis; it is usually associated with some inflammation of the serous layers. This is often a tuberculous process, originating in the mediastinum; it may be caused by the extension of a rheumatic pericarditis; some cases are obscure. The end-results are discussed in the succeeding section on chronic pericarditis with adhesions.



Pericarditis with effusion of blood is very rare in children. It may occur from the rupture of adhesions, from trauma, from blood diseases like purpura, and very rarely in tuberculosis.

**Symptoms.**—Pericarditis in infancy is usually overlooked because of its rarity and because it is often obscure; in some instances there are no characteristic clinical evidences.

The earliest sign is usually a friction rub, which may or may not be accompanied by acute local pain and tenderness. The typical rub is a to-and-fro, rough, leathery sound, heard close to the ear and synchronous with the cardiac cycle. It may be heard over the entire precordium or in several discrete areas; it may be confined to a small area at the base. The sound is not transmitted, though it may be very intense over the precordium; friction fremitus may be present. With the accumulation of fluid the rub may be heard only over a restricted area, but often persists at the base even though fluid may be present in considerable amount.

The signs of *pericardial effusion* are rapidly extending cardiac dulness, both to the left and to the right, and obliteration of the normal acute cardiohepatic angle with the formation of an obtuse angle. The area of dulness with small effusions is triangular or pear-shaped with the base below. With larger effusions the dulness may extend from the right mammary line or beyond it to the left axilla; the contour of the heart is then almost circular (Fig. 76) and the cardiohepatic angle again becomes acute. A widening of the area of parasternal dulness in the second space is an early sign, and its importance is enhanced if the area contracts markedly on moving the patient from a recumbent to a sitting position. There may be signs of pulmonic compression to the left of the vertebral column behind. The apex beat is feeble and may be displaced upward; it may disappear altogether. The cardiac sounds are diminished in intensity and may be almost inaudible; disproportion between the heart sounds and the pulse, when present, is of assistance in diagnosis—the pulse may be nearly normal when the cardiac sounds can barely be heard. In other instances, however, the pulse is feeble; it may become almost impalpable in inspiration (*pulsus paradoxicus*). A rapid increase in evidences of cardiac insufficiency should suggest an effusion.

The peculiarities of rheumatic pericarditis are discussed in connection with rheumatic fever. When pericarditis develops at the height of an attack of pneumonia, as it usually does, friction sounds are often masked by the pulmonary signs. There may be increased prostration with perhaps a more rapid and slightly irregular pulse and a change in the patient's color. Often the most striking sign is that cardiac sounds formerly distinct become feeble and distant, at times almost inaudible. In purulent pericarditis the amount of the effusion is generally much less than in the rheumatic forms, and its recognition from local physical signs is correspondingly difficult.

**Course and Prognosis.**—Pneumococcus pericarditis is almost invariably fatal in infants, and even in older children this is the usual termination. Occasionally, in the latter, resolution takes place before pus forms, or the pyopericardium which ensues is successfully drained. Purulent pericarditis from other causes is usually fatal; however, we have an instance of recovery with a staphylococcus aureus



infection. In the rheumatic cases the prognosis is serious, not so much because of the pericardial lesion itself as because this complication indicates a severe degree of myocardial involvement. Little is to be expected in the tuberculous cases; they are usually accompanied by advanced tuberculosis elsewhere, and though they may be chronic they are almost invariably fatal.

When recovery does occur in any form of pericarditis there are likely to be extensive adhesions between the layers of pericardium and perhaps external adhesions as well.

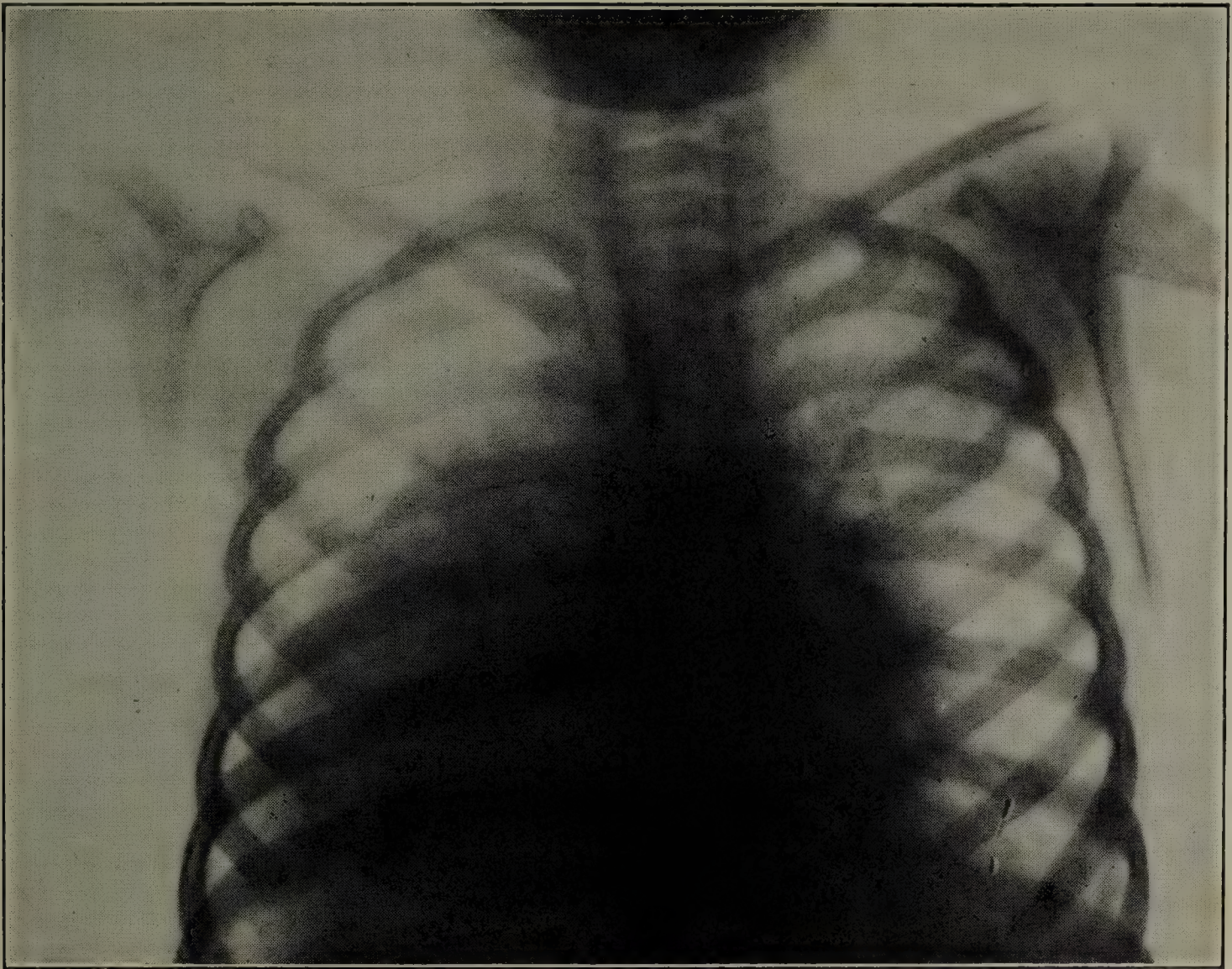


FIG. 76.—PERICARDITIS WITH EFFUSION.

Posterior view, showing moderate distention of the pericardium, especially to the left of the midline. Boy eight years old.

**Diagnosis.**—Pericarditis is recognized by knowing when to look for it—in infants with pneumonia, in older children with rheumatic fever. The difficulties in the diagnosis of dry pericarditis are greater in young children because of their rapid heart action; friction sounds must always be differentiated from endocardial murmurs. Purulent pericarditis complicating pneumonia, typhoid, scarlet fever or pyemia should be suspected with any unexplained change for the worse. Pericarditis with effusion may be difficult to differentiate from dilatation of the heart. Pericarditis usually develops more rapidly; a discrepancy between the intensity of the heart sounds or of the apex beat and the character of the pulse is a most helpful point. The diagnosis between serous and purulent effusions can be made only by aspiration.



**Treatment.**—In an attack of acute pericarditis the patient should be kept in bed, absolutely quiet. An ice-bag over the precordium or salicylates may do much to relieve pain; an occasional child will not tolerate ice, and dry heat may then be substituted. We have seen a number of patients experience relief when they were allowed to lean forward, resting their arms on a support. If the pain is not relieved by these measures, sedatives should be given without stint. Rheumatic effusions always subside spontaneously; we cannot recall a case in which aspiration was necessary, but it may be indicated at times for the relief of distressing symptoms. In tuberculous cases this may give temporary relief.

If aspiration shows the fluid to be purulent, incision and drainage should be practiced, as in empyema. The results from surgical intervention have not been brilliant, but more is to be expected than from aspiration alone.

### CHRONIC PERICARDITIS WITH ADHESIONS

Adhesive pericarditis is the result usually of single or repeated attacks of rheumatic pericarditis or of a tuberculous inflammation of the mediastinal tissues. Occasionally it follows pneumonia or other diseases. Adhesions may also be found postmortem when no previous illness has been recognized. The youngest case which has come under our observation was in a child sixteen months old, who died from acute pneumonia. The adhesions were old and general, the pericardial sac being completely obliterated.

The lesions depend upon the cause of the process. In the rheumatic form the pericardium is thickened and adhesions between the two surfaces are prominent; external adhesions between the pericardium and pleura are seldom extensive. In the tuberculous form, the thickening of the pericardium is often tremendous and all the intrathoracic organs may be bound together in a firm mass of scar tissue with obliteration of the pleural cavities as well. Panmediastinitis expresses well the distribution of the process, which may even extend through the diaphragm and surround the liver and spleen with a thick coating of new tissue. Throughout the adhesions caseous masses and fresh tubercles can be found. Other tuberculous lesions are usually present; tuberculous peritonitis is not uncommon. Cases of adhesive mediastinitis with abdominal involvement are not often met with in this country; the condition has been variously termed pseudo-liver cirrhosis or Pick's disease.

With adhesive mediastinitis there can often be demonstrated evidences of the adhesions and of passive congestion of the viscera. When the symptoms are well developed, the clinical picture is characteristic. The heart is firmly fixed; it does not move with change of posture. Cardiac dulness is very little altered by a deep breath. The lower borders of the lungs posteriorly descend very slightly with inspiration. There is a true systolic retraction at the apex, not in adjacent interspaces as is so commonly seen with greatly hypertrophied hearts. The ribs and sometimes the sternum can be observed definitely to be pulled toward the spine. The heart is enlarged and there may be a systolic murmur. Diastolic collapse of the jugular veins and pulsus paradoxicus may be recognized. Neither of these signs is of much importance for diagnosis. Often despite the absence of murmurs there are evidences of venous stasis. There is slight cyanosis, edema of the lower



extremities, enlargement of the liver and spleen, and from time to time ascites. Invasion of the peritoneum may be difficult to detect clinically; if the abdominal symptoms are unusually prominent, Pick's disease may be suspected. The course in any case is exceedingly chronic. The lesion is permanent and tends to increase. Some patients live years, now better, now worse, but the prognosis is uniformly bad. Medical treatment is purely symptomatic. Surgery may be indicated in selected cases in which the activity of the process has subsided. A number of procedures have been used to free the heart. *Cardiolysis*, Brauer's operation, in which several ribs are resected over the precordium, has been helpful in some instances. Complete pericardiectomy, as recently practiced by Beck, offers a greater promise of relief.

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## CHAPTER LVII

### DISEASES OF THE ENDOCARDIUM

#### ENDOCARDITIS AND VALVULAR DISEASE OF THE HEART

Endocarditis may occur even during fetal life; this is one of the rarer causes of congenital malformations; nothing is known about the etiological agent.

Rheumatic valvular disease is discussed elsewhere. There remain to be considered the acute and subacute forms of bacterial endocarditis.

**Acute Endocarditis (Malignant Endocarditis, Ulcerative Endocarditis).**—Acute endocarditis is not often seen in infants. It occurs in connection with some septic process—a septic wound, erysipelas, sometimes with pneumonia. In the days when sepsis of the newly born was frequent, many of these cases developed acute endocarditis. Any of the pyogenic organisms may be responsible—hemolytic streptococci, staphylococcus aureus, and various types of pneumococci are the most common. Less frequently the infection is due to an influenza bacillus, meningococcus or gonococcus.

The lesions produced by these various organisms differ in some respects, as is clearly shown in Thayer's monograph; the gonococcus, for example, shows a marked tendency to attack the right side of the heart. With any of these organisms the lesions are much more striking than in the rheumatic form; the vegetations are very large and there may be great masses of them nearly filling up the orifices. They may also extend to the mural endocardium. Valves may be perforated and chordae tendineae may rupture, the remaining portions of them being thickly covered by small vegetations. The valves of the left side of the heart are chiefly affected but there may be vegetations upon the tricuspid and even the pulmonary valves. The myocardium shows degenerative changes. Emboli are very common. They chiefly occur in the spleen, brain and kidneys. They may be found anywhere. If life is prolonged sufficiently these emboli are usually the starting points for abscesses.

The symptoms often give no evidence that the heart is involved. They are first those of a primary disease with the evidences of a severe septicemia superadded. The fever is high; it may be sustained or remittent in type; sweating is often profuse; in older children there may be chills. Anemia develops rapidly. Abscesses may appear and there may be loud heart murmurs, though these are sometimes slight or absent. The process is very acute and death occurs in the course of a few days or weeks. Organisms can almost always be cultivated from the blood.

**Subacute Bacterial Endocarditis (Streptococcus Viridans Endocarditis, Endocarditis Lenta, Ulcerative Endocarditis).**—Infections with the alpha-hemolytic (viridans) group of streptococci form a disease entity which merits separate consideration. These cases are not very common in childhood; only 5 per cent



of those collected by Thayer occurred in the first decade; among 50,000 admissions to the Harriet Lane Home only 15 cases were observed, the youngest being four years of age. The disease is much more chronic than other forms of bacterial endocarditis; its duration is usually a matter of several months, sometimes as long as a year. The *Streptococcus viridans* shows little tendency to attack normal heart valves; almost always the process is engrafted upon an old rheumatic lesion or upon congenital malformations.

The lesions are usually confined to the left side of the heart, and affect particularly the mitral valve. There are extensive vegetations of a grayish-green or pinkish-green color; these may affect the chordae tendineae and frequently extend into the left auricle. Myocardial changes are not striking; septic metastatic lesions caused by localization of the bacteria in other organs are not so marked as in malignant forms of endocarditis, although embolic phenomena are common enough in the skin, the brain, the spleen and the kidneys. The renal lesions are not necessarily of embolic origin, as Rich in particular has pointed out; there may be an acute nephritis apparently due to soluble exotoxins.

The disease manifests itself by cardiac, constitutional and embolic symptoms. The onset is insidious; it may be impossible to tell the exact time of its appearance. We have seen several instances in which it followed extraction of a tooth or tonsillectomy. There is a slowly increasing indisposition with slight fever, anemia, loss of appetite and perhaps dyspnea on exertion. The fever is low at first, but in the late stages may be high; it is of a hectic type. There may be periods in which the fever subsides, but it does not disappear entirely. Chilly sensations and rigors may occur in older children. Constitutional symptoms gradually become more pronounced. The anemia may become marked and the skin may assume a sallow appearance. Sooner or later embolic phenomena occur. Petechial hemorrhages may be found anywhere in the skin. Embolic lesions may also appear in the deeper layers of the skin or the subcutaneous tissues; they are pinkish or purplish, somewhat larger than petechiae, and are likely to be tender; they occur most often in the fingers and toes (Osler's nodes). Petechiae are common in the conjunctiva and retina; they may be found in the buccal mucous membranes, especially on the under surface of the tongue. There may be hematuria and sometimes other evidences of glomerular nephritis. As the disease progresses, embolic manifestations become more numerous. The skin may become covered with crops of petechiae. Infarcts in the spleen cause acute pain in the side and an increase in the fever. Enlargement of the spleen occurred in more than half of our cases; this is, however, not necessarily due to infarction. Clubbing of the fingers is seen in the more chronic cases. Cerebral emboli are common in the late stages; they produce hemiplegia, sometimes aphasia and stupor. The first ones are usually recovered from, but they are likely to be repeated and often terminate the picture. Heart murmurs, if present before, increase in intensity; new murmurs may appear; the murmurs are usually loud and rough, sometimes musical. Cardiac function is progressively impaired. The course of the disease is steadily downward; remissions are never complete. Death occurs at the end of weeks or months from toxemia, cerebral emboli or cardiac failure.

The diagnosis is easy enough when the picture is well developed, but early



recognition may be very difficult. A prolonged and unexplained attack of fever in a patient with rheumatic heart disease should make one suspicious; a careful search for petechiae and repeated blood cultures should be undertaken. Negative cultures may be obtained early in the disease, but as it progresses bacteriemia becomes constant and the number of organisms in the blood increases steadily. A leukocytosis of 20,000 is not uncommon. The blood serum has been shown to contain homologous agglutinins and complement fixation antibodies.

The isolation of a *Streptococcus viridans* from the blood does not imply the presence of this form of endocarditis. Such organisms are cultivated occasionally in rheumatic fever and in some instances of local sepsis. A repeated positive culture is, however, ominous.

Treatment is only symptomatic. Efforts to sterilize the blood stream by bactericidal drugs, by vaccines, or transfusions from immunized donors, have in our experience always been futile.

The picture of subacute bacterial endocarditis is occasionally caused by organisms other than the *Streptococcus viridans*. Instances due to staphylococci, hemolytic streptococci, influenza bacilli and other organisms have been described, but are rare. Infection with *B. Melitensis* (undulant fever) presents many clinical similarities.

### THE SIGNS OF SPECIFIC VALVULAR LESIONS

**Mitral Valve.**—Mitral lesions are among the rarest of congenital anomalies. The great majority of organic lesions of this valve are rheumatic in origin; some are due to bacterial endocarditis. Insufficiency of the mitral valve may be relative (or functional), due to dilatation of the auriculoventricular ring in the presence of myocarditis. In *mitral insufficiency* there is regurgitation of blood from the left ventricle to the left auricle during systole. There is a systolic murmur which masks or replaces the first sound and persists throughout systole; it is loudest at the apex, transmitted to the left, and is often heard at the angle of the left scapula; it may be heard over the entire left back or over the right scapula. The murmur may be soft and blowing or loud and rasping. A systolic thrill may be felt at the apex or just inside it. An incompetent mitral valve throws an added strain upon the left ventricle. Enlargement of the heart to the left, caused by hypertrophy and dilatation, follows regularly. Dilatation of the left auricle may be detected by an exaggeration of the second curve to the left on the x-ray shadow. Later on there may develop evidences of pulmonary congestion and the right heart may be affected, undergoing hypertrophy and dilatation. Pulmonary congestion leads to cyanosis; there may be evidences of consolidation or fluid at the bases; there may be hemoptysis. Pulmonary infarcts are not uncommon in marked cases, particularly when decompensation is present. Enlargement of the right heart may be detected by percussion or roentgenography. Exaggeration of the pulmonic second sound is characteristic of pulmonary congestion. It is important to remember, however, that the second pulmonic sound is regularly louder than the second aortic throughout childhood. The differentiation of mitral systolic murmurs from those of congenital lesions and accidental murmurs is taken up elsewhere.

A mitral diastolic murmur developing in a case of rheumatic heart disease with



mitral regurgitation does not imply that mitral stenosis is present. Such murmurs are heard comparatively early in the disease, long before the orifice is appreciably narrowed; they should be attributed to *mitral roughening*. The typical murmur occurs in the early part of diastole; in point of time it replaces the third heart sound. It is soft in quality and of short duration; it is usually best heard above and to the inner side of the apex, sometimes over a very limited area. The heart sounds may be represented by the whispered syllables "whoo-ta-whoo," in which the first syllable is the mitral systolic murmur, the second syllable is the second sound and the last is the early diastolic murmur, which is usually much shorter than the systolic murmur. The mode of formation of this murmur is still uncertain; it may be due to delay in opening of the mitral curtains owing to their stiffness; it certainly indicates sclerosis of the mitral valve; such cases may go on to develop a genuine mitral stenosis.

True *mitral stenosis* is a rare lesion in childhood. It requires years to develop and is probably always due to repeated attacks of rheumatism. It is usually associated with some degree of insufficiency. The picture, when well developed, is very characteristic. Cyanosis may be marked; the pulse is usually small. The proto-diastolic murmur of early mitral roughening may have disappeared entirely; the mitral systolic murmur may be less loud than before. The characteristic signs are a presystolic murmur and a striking alteration in the quality of the first sound. The presystolic murmur is a rough crescendo murmur sometimes described as a rumble and terminates abruptly with the first sound. It is loudest usually just inside and above the apex, and may be heard only over a circumscribed area. A "purring thrill" is a constant accompaniment, terminating sharply as the apex strikes the chest wall. The peculiar quality of the first sound is often described as "snapping" or "banging." Its ringing quality may be such that the novice readily confuses it with the second sound; accurate timing may be necessary in order to identify the sounds (see page 492). Between the picture of early mitral roughening with little or no stenosis, and that just described, which usually indicates an extreme "buttonhole" mitral contraction, all intermediate stages may be met with. Evidences of pulmonary congestion and secondary hypertrophy and dilatation of the right heart are found in all forms of advanced mitral disease.

**Aortic Valve.**—Aortic valve lesions are met with in the more severe cases of rheumatic heart disease. The signs do not as a rule become evident during the first attack, appearing only some weeks after the onset of the pathological process. Mitral disease is practically always present in addition.

*Aortic insufficiency* is much more frequent than stenosis. It implies regurgitation of blood from the aorta into the left ventricle during diastole. There is a diastolic murmur continuous with or replacing the second sound; it is generally loudest at the left border of the sternum in the third space, being transmitted downward toward the apex. There may be a pronounced thrill. This lesion is compensated for by hypertrophy and dilatation of the left ventricle which are often marked; the enlargement tends to be downward rather than outward as in mitral disease. With great hypertrophy there is often bulging of the precordium, producing striking thoracic deformity. Cases of extreme cardiac enlargement (*cor bovinum*) are usually the result of this lesion. A characteristic symptom is the



collapsing "water-hammer" pulse of Corrigan; there is usually a visible pulsation of the peripheral arteries, best seen in the carotids, with sudden distention followed by complete collapse of the walls. The pulse pressure, *i.e.*, the difference between the systolic and diastolic pressure, may be two or three times the normal; in marked cases no diastolic pressure can be recorded; a pistol shot sound can be heard over the arteries. A capillary pulse may be seen, but is not pathognomonic; it may occur in normal individuals with a comparatively slow heart; it can be demonstrated in the nail bed by pressure on the nail, but even more readily by rubbing the forehead until an area of erythema is produced, in the periphery of which pulsation takes place. The systolic pressure may be somewhat elevated; in some cases the systolic pressure in the legs is 30 or 40 millimeters higher than in the arms. Marked pulsation of the aortic arch can be seen in the fluoroscope; the electrocardiogram may show left ventricular preponderance.

A relative aortic insufficiency due to stretching of the aortic ring is described. We have seen one or two instances in which a faint aortic diastolic murmur disappeared in the course of days or weeks, where such a diagnosis seemed justified. Such cases are most unusual. Signs of aortic insufficiency are sometimes found with coarctation of the aorta, which may be attributed to stretching of the aortic ring from extreme dilatation of the arch.

*Aortic stenosis* of rheumatic origin almost never develops before the age of puberty. A child with signs of this lesion should make one suspect coarctation of the aorta; confirmatory signs of this condition should be sought. Aortic stenosis causes a systolic murmur loudest at the aortic area, transmitted upward; a marked thrill is present at the aortic area. The second sound is generally weak or replaced by a murmur. A small pulse and low pulse pressure may be found unless this is masked by signs of aortic insufficiency. Some hypertrophy of the left ventricle is invariably present; without this the diagnosis should not be made.

**Tricuspid Valve.**—This may in rare instances be attacked in rheumatic heart disease; usually there are more extensive lesions on the mitral and aortic valves which dominate the picture. Involvement of the tricuspid valve, when it does occur, comes late in rheumatic disease; insufficiency is far more common than stenosis. Certain bacteria like the gonococcus show a predisposition for the right side of the heart. Relative tricuspid insufficiency may occur with dilatation of the right ventricle. The primary cause may be cardiac disease or lesions outside the heart; anything which interferes with the pulmonary circulation may bring this about. It may follow emphysema, chronic interstitial pneumonia, chronic empyema or pneumothorax, congenital malformations of the lungs or thorax. The insufficiency is seldom permanent, but occurs during periods of decompensation. Tricuspid lesions produce symptoms of systemic venous obstruction. The jugular veins stand out prominently and often show systolic pulsation, especially on the right side. The venous blood pressure is increased. Enlargement of the liver is a prominent feature and there may be a systolic expansile pulsation of the liver in cases of tricuspid insufficiency. There may be a subicteric tint to the skin. Cyanosis and polycythemia are found in severe cases. Dulness to the right in the third and fourth interspaces suggests a dilated right auricle, which may be visible by x-ray. Right ventricular preponderance is characteristic. The murmur of tricuspid insuffi-



ciency is difficult to distinguish from that of mitral insufficiency, with which it is commonly associated. A systolic murmur heard best in the fourth left interspace close to the sternum is found in this lesion; a rough murmur and localized thrill should suggest organic insufficiency, provided congenital septal defects can be ruled out.

Tricuspid stenosis is a rare late rheumatic lesion usually accompanied by mitral stenosis. In tracings of the jugular pulse the auricular wave is unusually prominent. In some instances there have been early diastolic and presystolic murmurs heard in the tricuspid area. In the presence of fibrillation such signs are not found. It is rarely diagnosed during life.

**Pulmonary Valve.**—The signs of congenital pulmonary stenosis have been described elsewhere. Acquired disease of this valve is one of the rarest of occurrences. The diagnosis, when made, is usually incorrect. Pulmonary insufficiency is characterized by a diastolic murmur similar to that of aortic insufficiency, accompanied by no peripheral signs of aortic regurgitation. Such cases almost invariably turn out to be aortic disease, for the aortic murmur is the first evidence of that condition and appears some time before the peripheral signs. It is possible that x-ray and electrocardiography may aid in recognizing the occasional case, indicating which ventricle is more hypertrophied. Relative pulmonary insufficiency due to stretching of the pulmonary ring was described by Graham Steell, but is another diagnosis which is best avoided. Unlike the auriculoventricular rings, the semi-lunar valve rings are capable of only a very limited amount of stretching.

**Combined Valve Lesions.**—It is obvious that the signs of individual valve lesions may be considerably modified when more than one lesion is present. The development of stenosis is likely to diminish the signs of regurgitation in the same valve. Hypertrophy of one side of the heart may be masked by a more extensive lesion on the other side, causing greater hypertrophy there. In the diagnosis of multiple valve lesions, it is well to recall the comment of Osler, namely, that when lesions of more than two valves are diagnosed, mortifying postmortem disclosures are likely to follow.

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## CHAPTER LVIII

### DISEASES OF THE MYOCARDIUM

**Acute Myocarditis.**—Acute myocarditis is rare in childhood, except in association with rheumatic fever and diphtheria. It is occasionally seen with other infectious diseases—scarlet fever, typhoid, erysipelas, and in acute septic infections; some cases are obscure.

The lesion in the rheumatic cases—the Aschoff body—is described elsewhere. In diphtheria and other forms of toxic myocarditis the lesion is a diffuse parenchymatous degeneration (cloudy swelling); it often undergoes complete resolution. Fatty infiltration of the myocardial fibers is common. In other instances there are foci of hyaline degeneration or actual necrosis followed by scar formation. In certain severe infections, particularly scarlet fever, mononuclear round cells may infiltrate between the fibers. Where heart failure is associated with severe anemia, fatty degeneration of the heart is often found.

The symptoms are similar to those described in connection with rheumatic fever. The heart is usually rapid, bradycardia being exceptional; a slow heart may be due to sinus bradycardia or block. The quality of the heart sounds is impaired, particularly the first sound, which loses its muscular quality and becomes “flapping” in character. The pulse may be of poor quality and there may be a fall in blood pressure; irregularity, due either to extrasystoles or to varying degrees of block, may be found. Evidences of dilatation and a mitral systolic murmur may develop; this may be followed by the picture of cardiac insufficiency.

The severity of the process may not be evident, particularly if decompensation is absent; for this reason the prognosis must be guarded and every case treated conservatively. The treatment consists in *complete* rest in bed, to be continued for two to three weeks after the disappearance of signs. Death has resulted from such mild exertion as sitting up suddenly in bed. In the absence of circulatory failure, drugs are not indicated. Digitalis may do more harm than good, particularly if impaired conduction is present. Caffeine and epinephrine may be of help in combatting acute cardiac failure. Sedatives may be indicated.

**Myocardial Insufficiency (Cardiac Insufficiency, Congestive Heart Failure, Decompensation).**—This may be due to primary disease of the heart (acute myocarditis or its end-results) or to conditions outside the heart which throw an excessive burden on the circulation. Damage to the myocardium diminishes its capacity for work; valvular disease and pericardial adhesions handicap its efficiency and increase the amount of work to be done. An added strain may be thrown on the heart in conditions in which the peripheral resistance is increased: resistance in the pulmonary circuit rises in many thoracic diseases; in the systemic circuit it may be increased by any of the factors which cause hypertension. Most examples of congestive heart failure occurring in children are the result of rheumatic carditis or of



congenital malformations. However, we have seen several instances of acute nephritis accompanied by hypertension which developed cardiac dilatation and a mitral systolic murmur, the cardiac findings disappearing entirely with the fall in blood pressure during convalescence. Chronic interstitial nephritis with hypertension is seen every now and then in children and may cause cardiac signs and symptoms. Essential hypertension occurring at an early age has been described. Anemia as a cause of cardiac insufficiency is discussed elsewhere. The physician should not be too hasty in drawing the conclusion that acquired dilatation with a mitral systolic murmur is necessarily rheumatic, although this is true in the great majority of instances.

Cardiac failure may be acute, or may be chronic, developing insidiously. In general, the younger the child the more likely are the symptoms to be acute. Chronic progressive myocardial failure is comparatively rare before the sixth or seventh year, but thereafter it is common enough. Young infants with congenital heart lesions are likely to develop paroxysmal attacks with cyanosis, dyspnea and perhaps syncope; these may last but a few minutes or hours and then clear up entirely. They are possibly due to acute dilatation of the heart. A fatal attack with edema of the lungs may occur in a patient who a few hours before was symptom-free. Young children with rheumatic heart disease are less apt to exhibit these sudden paroxysmal attacks; they may have periods of decompensation lasting for weeks and coinciding in duration with acute rheumatic attacks. Myocardial failure applies to the heart as a whole; we no longer attempt to differentiate between auricular and ventricular, or between right and left, failure. Clinically, however, it is a striking fact that in children the symptoms are usually pulmonary (dyspnea, orthopnea) or hepatic (enlargement of the liver), rather than due to peripheral stasis (edema, anasarca). The extreme forms of circulatory stasis are seen in older children who have suffered from heart disease for many years; they appear to result not so much from an acute myocarditis as from a myocardium exhausted by prolonged overexertion.

The first evidence of failing cardiac compensation is usually dyspnea. At first this is noticeable only after exertion. Since there are marked differences in individuals, *increasing* dyspnea is of particular significance. Sometimes the dyspnea is accompanied by palpitation, headache or a feeling of suffocation, or by a slight cough. Spirometer studies often show a decrease in vital capacity while the patient is relatively symptom-free when quiet. With more marked degrees of decompensation the dyspnea becomes continuous and orthopnea may be present in addition. Cough at this stage is dry and persistent, with some of the ringing quality associated with mediastinal pressure. Later there may be profuse expectoration with streaks of blood or with pinkish, frothy sputum. Signs of passive congestion or of pleural effusion may appear at the lung bases, especially on the right side. Edema may be of slight degree and evenly distributed; the weight of the body on a crease in the clothing leaves a pattern in the skin; the bell of the stethoscope leaves its imprint after auscultation. These signs may be present when there is no pitting edema over the shins or over the sacral region. Other cases show pitting edema which may begin in the face as in acute nephritis; eventually it goes on to general anasarca with effusions into the serous cavities, especially the peritoneum



and the pleura, rarely into the pericardium. Chronic passive congestion causes the liver and spleen to become enlarged. The descent of the liver border is one of the most characteristic features of cardiac failure in children and is a far more valuable criterion of severity than the amount or distribution of edema. While the liver is enlarging, and as long as it is tender, circulatory insufficiency is increasing. Pulsation of the liver, accompanying tricuspid insufficiency, is rather uncommon in childhood. There may be a subicteric tint to the skin, due to increased bilirubin in the blood. Pallor is more common than cyanosis. The skin may be clammy or covered with profuse perspiration. Digestive symptoms—belching, nausea and vomiting—may be distressing. Congestion of the kidneys may lead to albuminuria, cylindruria and impaired renal function as shown by functional tests and by oliguria. Cerebral symptoms—headache, dizziness and fainting attacks—may occur.

The signs in the heart itself are variable. Enlargement is always present, due to hypertrophy and dilatation; the latter usually predominates with advanced decompensation. Any of the evidences of a damaged myocardium may be found: poor heart sounds, feeble pulse, a diffuse, rippling precordial impulse, gallop rhythm, extrasystoles. Signs of insufficiency of the auriculoventricular valves are always present, but the murmurs may be so confusing and so difficult to interpret that it is usually prudent to postpone accurate diagnosis of the valve lesions until compensation is in some measure restored. Auricular fibrillation is rare in children and occurs almost exclusively in older children with long-standing heart lesions.

Cardiac pain is a very striking feature of some cases; it may be mild or absent in others. At times it is paroxysmal and comes in attacks lasting but a few minutes. It is usually seen in cases with advanced decompensation. The pain is generally limited to the precordium or to portions of it; less commonly does it radiate down the left arm, up the neck, or to the epigastrium. Paroxysms of severe pain are accompanied by sweating and pallor; areas of hyperesthesia may persist following the paroxysm. The cause of this pain is obscure. It is by no means confined to patients with aortic disease. We have seen a number of fatal attacks in which the symptoms simulated those of coronary occlusion as seen in the adult, but for which no explanation was found postmortem. Paroxysmal nocturnal dyspnea (cardiac asthma) is exceedingly rare in children.

The course and prognosis in a case of cardiac insufficiency will depend upon its underlying cause. This is discussed in connection with the diseases in which decompensation is likely to occur, particularly rheumatic fever. There is always the possibility in any form that sudden death may supervene with acute dilatation of the heart and edema of the lungs.

Improvement in compensation is usually accompanied by a subjective sensation of relief and calm on the part of the patient. The most valuable objective criteria of the course of the condition are the pulse rate, the size of the heart—particularly the location of the right border—the strength of the heart sounds, the signs at the lung bases, the size of the liver, and, in patients with edema, the output of urine and the weight.

The treatment is discussed in connection with rheumatic fever, the condition in which cardiac insufficiency is most often met with in children.



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## CHAPTER LIX

### DISEASES OF THE BLOOD VESSELS

**Hypertension.**—Hypertension, unconnected with demonstrable organic disease, is not common in children. Before the school age, the most frequent causes of elevated blood pressure are renal insufficiency, increased intracranial pressure, and acrodynia. Amberg reviewed 25 cases in children ranging in age from six to sixteen years. Some were of temporary duration, associated with intracranial lesions, cardiac decompensation, and sometimes with various forms of kidney disease. In 3 the blood pressure was elevated only in the upper part of the body and was dependent on congenital coarctation of the aorta. Still others showed a variety of signs indicative of organic disturbance. No clear-cut cases of “essential hypertension” could be found.

Often when a high pressure is obtained at the first examination, a repetition under more favorable emotional conditions will give a normal figure. The Sehams long ago pointed out that in children the blood pressure is often higher in the recumbent than in the sitting position, and that it may be lowest in the standing position.

**Arteriosclerosis.**—Arteriosclerosis has been reported even in newly born infants. We have seen extensive atheromatous plaques in a child dying at the age of six weeks. Tortuous pulsating arteries may call attention to the condition. Death may occur with cerebral accidents as in adults.

Other types of arterial calcification are sometimes encountered in infants and young children which are quite distinct from atheromatous degeneration. The media of the artery is primarily affected and the peripheral arteries suffer as much or more than the larger trunks. In such cases there may be no symptoms. The etiology in most instances is completely obscure; it is possible that parathyroid dystrophy may at times play a part. Syphilitic disease of the aorta is exceedingly rare in children.

**Aneurysms.**—Aneurysms of the larger vessels have been reported. Perhaps the youngest case on record is that of Sanné, in which a large aneurysm of the abdominal aorta was found in an eight months' fetus. Heiman has collected 10 cases of aortic aneurysms in young children; the arch was the usual seat. Most of these were attributed to syphilis; others to tuberculosis or whooping cough. It is probable that congenital anomalies of development are a more important etiological factor than has been supposed. The symptoms and course of aneurysms in childhood do not differ from those of adult life.

Mycotic aneurysms are occasionally met with in septic conditions; they are usually small. Traumatic aneurysms need only to be mentioned. The most important and most interesting group of aneurysms seen in childhood are the congenital cerebral aneurysms, described under Diseases of the Nervous System.



**Embolism and Thrombosis.**—The liberation of large emboli, giving rise to sudden shock or to pulmonary, cerebral, renal or splenic symptoms, is uncommon in early life. Small emboli are discharged in bacterial endocarditis and contribute to its characteristic clinical picture. Some of the instances of thrombosis in infectious diseases are unquestionably due to emboli; others are due to bacteria which damage the vessel wall without occluding it.

Thrombosis, whether of arteries or veins, is usually infectious in origin. Diseases in which thrombosis is more commonly found are typhoid fever, scarlet fever and diphtheria. Cases in newly born infants are usually due to sepsis. The veins are more commonly affected than arteries. Circulatory stasis and external pressure upon blood vessels may initiate thrombosis. Small pulmonary infarctions are not uncommon in conditions of cardiac decompensation; stasis with resulting thrombosis seems to be responsible here. Pressure upon the great veins from tuberculous lymph nodes may lead to thrombosis. We recently saw an instance of thrombosis of the vena cava, associated with a congenital transposition of the great vessels. Other factors which may cause thrombosis are trauma and degenerative diseases of the arteries.

Agonal thrombi are sometimes formed in the heart in the last few hours of life; they are of no clinical importance.

**Arterial Thrombi.**—Thrombosis of the aorta or of any of its larger branches is rare; instances in which this occurred in congenital syphilis and in septic infections are recorded. When the larger arteries are occluded sudden death occurs. Occlusion of the smaller vessels leads to dry gangrene unless adequate collateral circulation is possible.

**Venous Thrombi.**—The most important group of venous thromboses are those of the cerebral sinuses; these are taken up under Diseases of the Nervous System. Thrombosis of the great veins—either the inferior or the superior vena cava alone—may be compatible with life. The localization of venous thrombi can often be determined by a careful study of the distribution of edema and of the collateral circulation. With thrombosis of the inferior vena cava there is marked swelling and edema of the lower extremities, which may extend to the abdomen and groin. The superficial veins of the abdomen are usually greatly dilated and tortuous.

Thrombosis of the internal jugular vein may be primary or may represent extension downward of a thrombus in the lateral sinus and jugular bulb. The symptoms are swelling, edema and cyanosis of the face. The Queckenstedt test may be of help in diagnosis; in some cases the thrombosed jugular is palpable.

Thrombosis of the abdominal vessels may cause symptoms which are less easy to interpret. Mesenteric thrombosis causes symptoms of acute intestinal obstruction; gangrene develops in the segment affected and peritonitis follows. It is usually impossible to tell clinically whether the thrombosis is arterial or venous. Thrombosis of the splenic vein produces great enlargement of the spleen and hematemesis. Thrombosis of the portal vein is not so very uncommon; we have seen it develop during the first few weeks of life, apparently due to a subacute septic condition entering by the umbilicus. The symptoms may not be very striking if the condition develops slowly, as it is likely to do. An enlarged liver, ascites,



enlargement of the spleen and melena may be present; the superficial veins of the abdomen may be dilated.

**Periarteritis Nodosa.**—In this disease, which is generally believed to be a systemic infection of undetermined etiology, the smaller arteries in various parts of the body show focal areas of degeneration in the media and adventitia with exudation of fibrin and cellular infiltration. The lumen of the vessel may become occluded, or the wall may be weakened in such a way as to cause the formation of an aneurysm; hemorrhage may take place. In many cases the pathological changes escape notice until the material is studied microscopically. The disease is definitely more common in males. A few cases have been associated with active rheumatic fever, and at autopsy have exhibited typical Aschoff bodies in the myocardium.

The symptoms vary greatly, depending on the location of the affected arteries, and may lead to a confusion of erroneous diagnoses. There may be vague, shifting pains in various parts of the body. Sometimes there is muscular weakness or paralysis. In other cases cutaneous symptoms are in the foreground—there may be crops of erythematous or purpuric lesions. Hemorrhages may occur in any part of the body. Sometimes local symptoms are wanting and the picture is one of progressive weakness and anemia and shortness of breath. Constitutional symptoms are rarely wanting; most characteristically there is a low grade fever; perspiration may be profuse. Moderate hypertension is of relatively common occurrence, and there may be nitrogen retention; but, apart from renal hemorrhage when it occurs, the urinary findings are insignificant and inconstant. The most constant change in the peripheral blood is a relative increase in the polymorphonuclear neutrophiles without much change in the total white cell count. Blood cultures are invariably sterile. Nodules occurring along the course of arteries should be sought by repeated and painstaking palpation, but failure to detect them does not by any means eliminate the diagnosis. A positive identification of the disease during life is possible only with the aid of biopsy material.

So rarely has the condition been recognized before death that its true prognosis is not known. Treatment is purely symptomatic.

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## SECTION IX

### DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS

#### CHAPTER LX

#### HEMATOPOIETIC ACTIVITY IN EARLY LIFE

**The Blood During Fetal Life.**—As explained elsewhere, the fetal circulation is an inefficient respiratory arrangement. Only by a “compensatory hypertrophy” of the blood—an increase in red cells and hemoglobin—can respiration be adequately maintained. In addition to this polycythemia, the blood of the fetus is characterized by an abundance of immature forms, both red cells and leukocytes. The adaptation to the postnatal period begins during the last month or two of fetal life. During this period the red count and the hemoglobin diminish; iron from the destruction of red cells begins to accumulate in the liver; nucleated red cells diminish in the peripheral circulation. After birth, these changes occur more rapidly.

TABLE XXXIX  
BLOOD CHANGES IN INFANCY \*

Age	Hemo- globin, Per Cent †	Red Blood Corpuscles	Reticulo- cytes, Per Cent	White Blood Corpuscles				Platelets
				Total Number	Polys.	Lymph.	Mono.	
					Per Cent			
1st day ....	120	5,500,000	2-5	20,000	60	30	10	350,000
3rd day ...	115			13,000				
6th day ....	110	5,000,000						
10th day ..	100		1	12,000	30	62	8	300,000
12th day ..	95	4,800,000						
3 months ..	80		0.5	10,000				
2 years ....	75-80	4,500,000	1		47	47	6	300,000
5 years ....	85	4,500,000		8,000				
10 years ...	90	5,000,000	1		62	30	8	300,000

\* The figures given in the above table are averages. They are taken from Williamson, Lucas, Lippman, Forkner, Blackfan, and other sources.

† 100 per cent is taken as 16 grams hemoglobin per 100 c.c. blood.

Shortly after birth the red cells and the hemoglobin begin to fall from their abnormally high level. This decrease is at first rapid, but gradually becomes slower. The low point is usually reached at about the middle of the first year, but there is little increase until after the second year. After this time there is a gradual rise continuing up to puberty. In children under two years old the usual range in



the hemoglobin is between 65 and 85 per cent, measured with the Newcomer standard. Nucleated red cells are regularly found on the first day of life, but are uncommon thereafter. In premature infants they may persist for many weeks.

A polymorphonuclear leukocytosis is regularly found in the newly born, varying between 15,000 and 35,000. This is a very transient phenomenon, and has disappeared completely by the tenth day. Great variations are found in the total white count of infants as compared with older subjects. During the first year or so a white count of 15,000 need not be regarded as significant. Even in later childhood normal individuals often exhibit counts as high as 12,000. The normal differential count of the infant shows a preponderance of lymphocytes, which constitute 60 to 70 per cent of the white blood cells. This characteristic is apparent by the tenth day, since the leukocytosis of the newly born will have disappeared by that time. The percentage of polymorphonuclear cells gradually rises during childhood. At two or three years of age most children show equal numbers of granulocytes and lymphocytes in the blood; the normal adult differential is attained at about the tenth year. Myelocytes are rarely found after the first day of life.

The infant tends to react to infections by higher leukocyte counts than does the adult; in typhoid fever, for example, there may be leukocytosis rather than leukopenia. A tendency toward a lymphocytosis is not uncommon in infections and anemias in childhood.

Another characteristic of the child is the striking tendency of the marrow to put out immature forms in response to strain. Young red cells and white cells frequently appear in the circulation in such conditions. Even when no myelocytes are found, the polymorphonuclear cells assume a more immature appearance.

According to the Schilling method, polymorphonuclear neutrophils may be divided into 3 main classes in the differential count, depending upon the maturity of the cell as shown in the size and shape of the nucleus: (1) young forms, with large bean-shaped nucleus; (2) rod-forms, with more compact rod-shaped nucleus; (3) segmented forms, with the lobulated nucleus of the mature cell. A differential count containing 50 per cent neutrophils might show at any period of infancy or childhood a distribution of, perhaps, 1 per cent of young forms, 8 per cent of rod-forms, and 41 per cent of segmented forms, or as the Schilling count is usually reported, 1-8-41. In response to stimulation of the leukopoietic marrow, a so-called shift to the left takes place; the distribution might then be 2 per cent of young forms, 20 per cent of rod-forms, and 28 per cent of segmented forms, or 2-20-28. The shift to the left may accompany or be independent of a change in the percentage of neutrophils or an increase in the total white cell count. Young individuals respond in this way much more readily than adults. In conditions of bone marrow exhaustion, the shift to the left fails to take place, and in extreme cases all of the neutrophils present are of the adult, segmented variety.

### POLYCYTHEMIA

Polycythemia occurs as a response to defective oxygenation of the blood. The polycythemia of fetal life and of the newly born has already been referred to. Polycythemia may occur in chronic pulmonary or cardiac disease, and is particularly striking in certain cases of congenital heart disease. The polycythemia produced by high altitudes belongs to this group.

Disturbances in water metabolism which cause a diminution of plasma volume



give rise to a polycythemia of the peripheral blood, although the total red cells and hemoglobin of the body are not increased. Dehydration is the commonest cause of this type of polycythemia. Certain drugs, for example adrenalin, have been shown to produce polycythemia by liberating stored red cells from the spleen.

There has been some question as to whether *polycythemia vera* (Osler-Vaquez disease) occurs in children. It is certainly extremely rare, but in the cases reported by Wieland there seems to be little room for doubt that this disease was present. He observed 6 cases in a family of 8 children whose mother was suffering from typical polycythemia vera. With the exception of splenomegaly, which was not noted in these children, the symptoms were those of the adult disease; there were headaches, dizziness, tinnitus; the cyanosis was very striking. Some of the children showed hemorrhagic manifestations. Physical development and ossification of the epiphyseal centers was delayed. A case associated with gigantism has, however, been reported by Stoye. Treatment with phenylhydrazine, which has proved the most satisfactory measure for this disease in adults, does not appear to have been tried in children.

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## CHAPTER LXI

### THE ANEMIAS OF CHILDHOOD

**General Considerations.**—The anemias of childhood differ in many respects from those of later life. Not only are the causes of anemia different, but the response to a particular agent differs both qualitatively and quantitatively. In the group of primary anemias, true pernicious anemia probably does not occur before the age of puberty; the same may be said of that fast-disappearing disease—chlorosis. On the other hand various types of congenital primary anemia are encountered only in early life. Many of the factors causing secondary anemia operate in children and adults alike. Neoplasms are not an important cause of anemia in children. Certain factors peculiar to early life—such as defective nutrition and immaturity—tend to make the infant particularly subject to anemia. Infections play a very important part in the anemias of childhood; the hematopoietic system of the infant seems to be peculiarly susceptible to them.

In older children and adults, secondary anemia can usually be attributed to a single cause, but in infants this is frequently impossible: immaturity, defective nutrition and infection may all play a part in an individual case. Premature infants are particularly susceptible to anemia from any other cause. Anemic babies in general are prone to infections and thus a vicious circle is established. Moreover, an infection, because of the marked iron loss which may accompany it, may be the starting point for nutritional anemia; it also predisposes to nutritional anemia by impairing the child's appetite.

A classification of anemias on an etiological basis has obvious drawbacks, but we have retained it for the reason that such types can often be clearly separated and because the therapeutic response is frequently characteristic. In the following discussion certain general characteristics of anemia and the reaction of the child to anemia will be taken up, after which specific types of anemia will be described.

**Pathology.**—Anemias are of two general types: those due to defective blood formation (hypoplastic anemias) and those due to increased blood destruction (hemolytic anemias). The term hypoplastic as here used refers to a blood picture characterized by a deficiency of young forms. It is not always possible to correlate this with the anatomical condition found in the bone marrow. The hemolytic anemias may be compensated for to a variable extent by increased blood formation; if this fails to occur a rapidly progressing anemia develops.

Hemolytic anemias show definite changes in pigment metabolism. A yellowish-brown iron-containing pigment *hemosiderin* accumulates in the liver, spleen and other organs, and may be sufficient to cause gross discoloration; this pigment is most abundant in the phagocytic cells, but is found in the parenchymatous tissue as well. When blood destruction occurs with great rapidity free hemoglobin appears in the blood serum and is excreted in the urine, but as a rule most of the hemo-



globin is converted into bilirubin, leading to icterus which may be very marked. Even when blood destruction is insufficient to cause icterus or an increased bilirubin in the blood there can be detected an increase in the urobilin output in the stool. Urobilinuria occurs only with a marked increase in urobilin formation or in the presence of hepatic damage. Enlargement of the spleen is striking in many instances of hemolytic anemia. In these cases it has often been shown that increased phagocytosis of red cells occurs in the spleen and is related to its enlargement. But it is doubtful that such phagocytosis is ever the sole factor in the increase in size of the spleen, or that it is primarily responsible for the anemia, even in cases of hemolytic jaundice. Probably only red cells which are senile, damaged or otherwise abnormal are so phagocytized. Phagocytosis of red cells by monocytes can often be demonstrated in fresh blood preparations in cases of hemolytic anemia. This finding is of some diagnostic importance. It has been frequently observed in hemolytic jaundice and in sickle cell anemia. Abt observed it in a newly born infant.

The response of the hematopoietic tissue in anemia is variable. The leukoblastic marrow is likely to be affected similarly to the erythroblastic marrow as regards hyperplasia or hypoplasia. In extreme aplastic conditions the marrow consists almost entirely of fat and connective tissue. The most striking contrast to the reaction of the adult is seen in the anemias accompanied by increased blood formation; regenerative phenomena are much more conspicuous in early life. Extramedullary blood formation is a frequent occurrence in infants with severe anemia: blood islands develop in the capillaries of the liver, in the splenic pulp and sometimes in the kidney or other organs. In the child hyperplasia of the bone marrow may be accompanied by changes in the structure of the bones—an increase in spongy trabeculated bone and pressure atrophy of the cortex. The most extreme instances of secondary bone changes have been in cases of primary erythroblastic anemia (Cooley) in which alterations in the contour of the bones were noticeable externally.

Attention has recently been drawn to the occurrence of liver damage in anemia. Severe cases may exhibit central necrosis. Harrop and Barron have shown by means of bilirubin excretion tests that impairment of liver function is very frequent. According to Bumstead, Barron and Rich the injury results from anoxemia.

**The Blood Picture.**—Most anemias of childhood are of the chlorotic type with a color index below 0.7 and sometimes as low as 0.4 or 0.35. The average diameter of the red cells tends to be small. All grades of anisocytosis and poikilocytosis are met with. As in older patients, hypoplastic forms are occasionally encountered; there may be decreased formation of erythrocytes, of leukocytes of the myeloid series, or of platelets, or any combination of these. In anemias accompanied by bone marrow stimulation, the response is likely to be much more striking than in the adult; and there is a greater tendency to revert to the fetal type of blood picture. It is by no means uncommon to find nucleated red cells—even megaloblasts—in abundance. The response of the white cells may be conspicuous; there may be either a leukocytosis or lymphocytosis in which young forms are often abundant. The platelets may be markedly increased.

**The von Jaksch Syndrome.**—In 1889 von Jaksch described as a primary anemia of childhood (*Anemia Pseudoleukemica Infantum*) a condition which still



bears his name, although the names of Hayem, Luzet, Cardarelli and others are sometimes attached to it. The characteristics of this condition are: a severe anemia with low color index associated with marked evidences of regeneration; a leukocytosis in which cells of the granular series predominate, young forms being abundant; marked enlargement of the spleen and variable enlargement of the liver and lymph nodes. The condition as described responds poorly to treatment; its frequent association with rickets has been noted.

As observations have accumulated many doubts have been raised as to whether this condition is a primary anemia. No sharp line can be drawn between these cases and the ordinary secondary anemias of childhood. The von Jaksch picture may be present in its entirety, or one or more of its characteristic features may be observed independently; there appears to be no constant relation between them. In some instances a definite etiological factor can be found. For these reasons many authors prefer to speak of the von Jaksch syndrome rather than of von Jaksch anemia, regarding it as a type of infantile response.

It is probably desirable to drop the term "von Jaksch anemia" entirely, for this group of cases is not a homogeneous one and includes instances of secondary and of primary anemia. Cooley has recently described a group of anemias with the von Jaksch picture which can hardly be regarded as anything but a primary constitutional disease. This condition (primary erythroblastic anemia) is described elsewhere.

**Symptoms of Anemia.**—It is surprising how well the infant withstands anemia; symptoms are rarely observed unless the hemoglobin falls below 30 per cent. The nutrition is usually excellent even in long-continued cases. Pallor of the skin and mucous membranes may be present, but is a most deceptive criterion. One often encounters marked pallor in subjects who are not anemic (*Scheinanämie*), and except in severe cases the anemic child may not appear especially pale.

Severe anemias as a rule give symptoms although it may be difficult to distinguish these from those of the underlying cause. In the most severe cases there are evidences of myocardial insufficiency; this is due to anoxemia, which impairs the efficiency of the heart and at the same time increases the demands upon the circulation. There may be only a systolic murmur with little or no cardiac enlargement, or there may be definite cardiac dilatation with all the evidences of congestive failure.

Older children are more likely to have symptoms with a moderate degree of anemia. The older child is better protected against anemia, and the breakdown of his defense indicates a process of more gravity than in the infant. Infections are responsible for the great majority of anemias in older children. Most of these patients are malnourished; they are irritable and easily fatigued; sleep is disturbed and enuresis is a common complaint. They may suffer from fainting attacks; the peripheral circulation is poor and the hands and feet are likely to be cold. Well-defined manifestations of cardiac insufficiency occur only in severe cases.

Jaundice may be present in hemolytic anemias. Purpuric manifestations are associated particularly with anemias of infectious origin. In some instances this



can be attributed to diminution of the platelets; in other instances the platelets are not decreased and it seems probable that damage to the capillary walls by the infectious agent is responsible.

The various types of anemia in childhood will now be described. The diagnosis and treatment of anemias will be taken up subsequently.

## SECONDARY ANEMIAS

**Physiological Anemia.**—As already stated a certain degree of anemia in infancy may be regarded as physiological. This cannot be explained on the basis of excessive blood destruction. Increased blood destruction does occur during the early days of life, but can rarely be demonstrated after the second week. The continued fall of hemoglobin and red cells and their persistence at a low level must be attributed to an inability of the hematopoietic tissue to meet the demands of blood formation, which are probably great at this time owing to the rapid growth of the body. The observations of Mackay, Josephs and others have shown that the hemoglobin can be raised by intensive iron therapy during this period of physiological anemia, although perhaps not to the normal level.

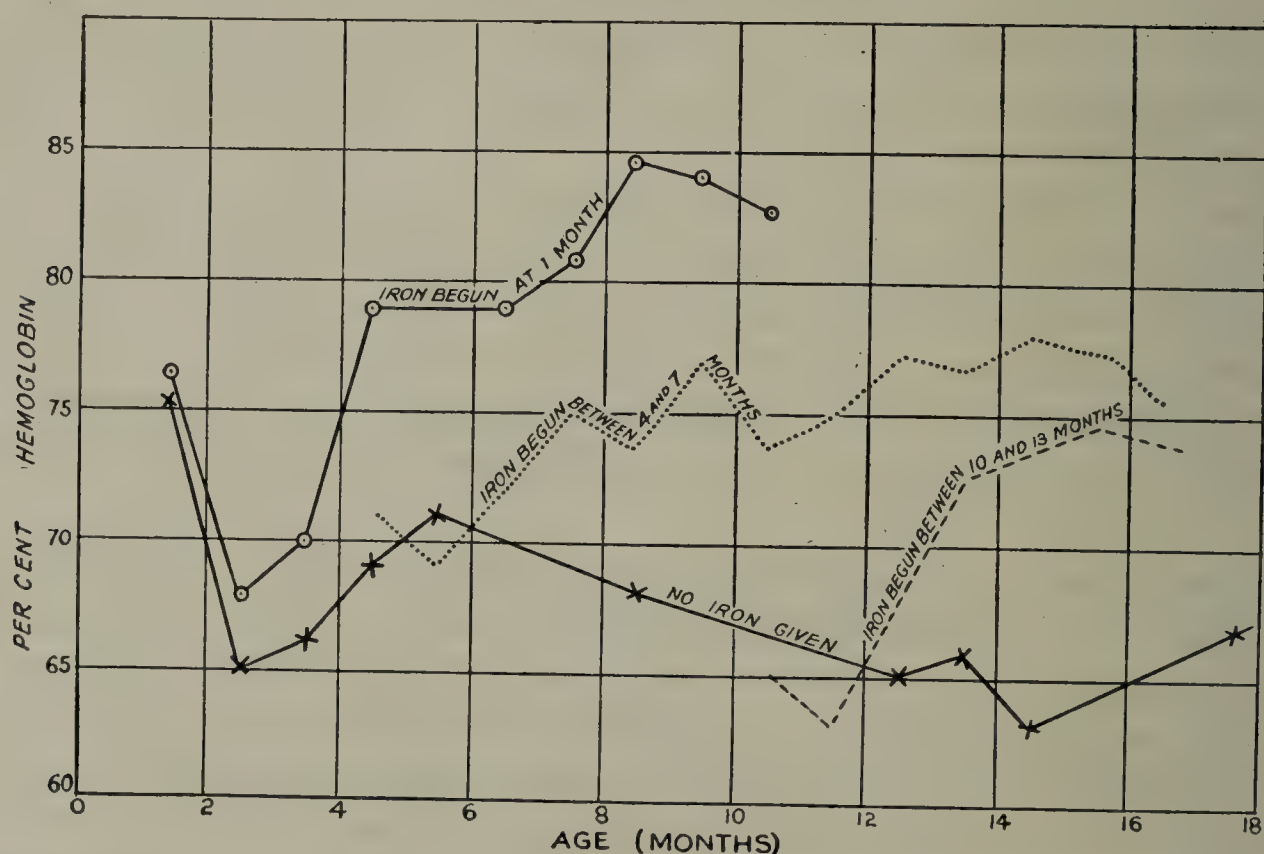


FIG. 77.—EFFECT OF IRON ADMINISTRATION ON HEMOGLOBIN OF NORMAL INFANTS.  
(From Mackay, Special Report No. 137, Med. Res. Council, London, 1931.)

**Anemia of Prematurity.**—The premature infant develops a moderately severe anemia with great regularity, but the changes in the blood picture occurring after birth differ in certain respects from those in full term infants. The fall in hemoglobin and red cells may begin as promptly as in normal infants, or it may be somewhat delayed; values almost as high as those on the first day of life are sometimes found at the end of the second or third week. Young red cells and white cells remain in evidence throughout this period. It is probable that this persistence of the fetal blood picture is to be explained by delayed closure of the fetal circulatory passages. When the decline in red cells and hemoglobin does commence it is



likely to be more rapid than in the mature infant; blasts disappear from the blood at this time. The lowest values are found at the end of the third or during the fourth month, the hemoglobin being 50 per cent or less at this time. The duration of this anemia is somewhat longer than that of the physiological anemia occurring in the normal infant. The character of the anemia at its height is usually hypoplastic.

The usual explanation for anemia of prematurity dates from the observations of Bunge and of Hugounenq, who noted the accumulation of iron in the liver during the latter part of fetal life. Presumably the premature infant born before this store had been laid down was poorly equipped for a period on an iron-poor diet; lack of iron was regarded as the cause of his anemia. In recent years it has been suggested that lack of copper is responsible for this anemia. It has been shown that the liver of the full term infant is richer in copper, and it is easy to believe that this is of physiological significance.

However, a number of facts speak against a deficiency of either iron or copper as the cause of this anemia. Iron alone or with copper is not as effective a remedy as one would expect if this were the case. Lichtenstein found that premature infants had a negative iron balance during the early months, which suggests that they are unable to utilize properly even such iron as is present. On the whole it seems likely that the anemia of prematurity is merely an exaggeration of the so-called physiological anemia. Growth in the premature is relatively more rapid than in the mature infant, and it would appear that even when the building materials and stimuli for blood formation are adequately supplied, the bone marrow is unable to meet the demands made on it.

Prematurity anemia can be prevented entirely or can be cured by means of frequently repeated transfusions, but the anemia is rarely severe enough to justify such treatment; if cardiac symptoms develop transfusions may be given. It has been the experience of Josephs, working in the Harriet Lane Home, that at the height of the anemia the bone marrow does not react to stimuli; neither iron, copper nor liver produces any notable effect. (Fig. 78). The duration of this refractory period is variable, and after a time the power of responding gradually develops. Landé, however, has reported favorable responses from iron in infants only two or three months old. On the whole it would seem desirable to supply the premature infant with iron from the start, so that it will be available as soon as he can utilize it. Copper or liver may be introduced from time to time and continued if a therapeutic response follows. The dosage of iron and copper is given elsewhere. When the infant reaches the age of six months a mixed diet may be substituted for copper and iron therapy.

**Nutritional Anemia.**—Anemia frequently occurs when lactation is unduly prolonged or when an exclusive diet of milk or infant foods has been continued into the second or third year. Individual infants, however, vary greatly in their susceptibility to such diets. The anemia is often hypoplastic in type, but all variations are seen between this and the von Jaksch picture. Increased blood destruction is rarely conspicuous; if marked, it should lead one to suspect that infection or some other cause plays a part.

Nutritional anemia has been variously ascribed to: (1) lack of substances con-



taining the pyrrol ring, such as chlorophyll and certain amino acids; (2) lack of iron, and (3) lack of copper. Milk is relatively poor in all of these substances. The evidence pointing to a pyrrol deficiency is not very convincing. Experimental milk anemia in rats has been improved by the addition of pyrrol derivatives; some observers have found green vegetables more effective in hemoglobin production than their ash alone. However, even if one grants the correctness of these observations for experimental animals, it does not follow that milk contains insufficient pyrrol substances for human economy. The fact that nutritional anemia in infants

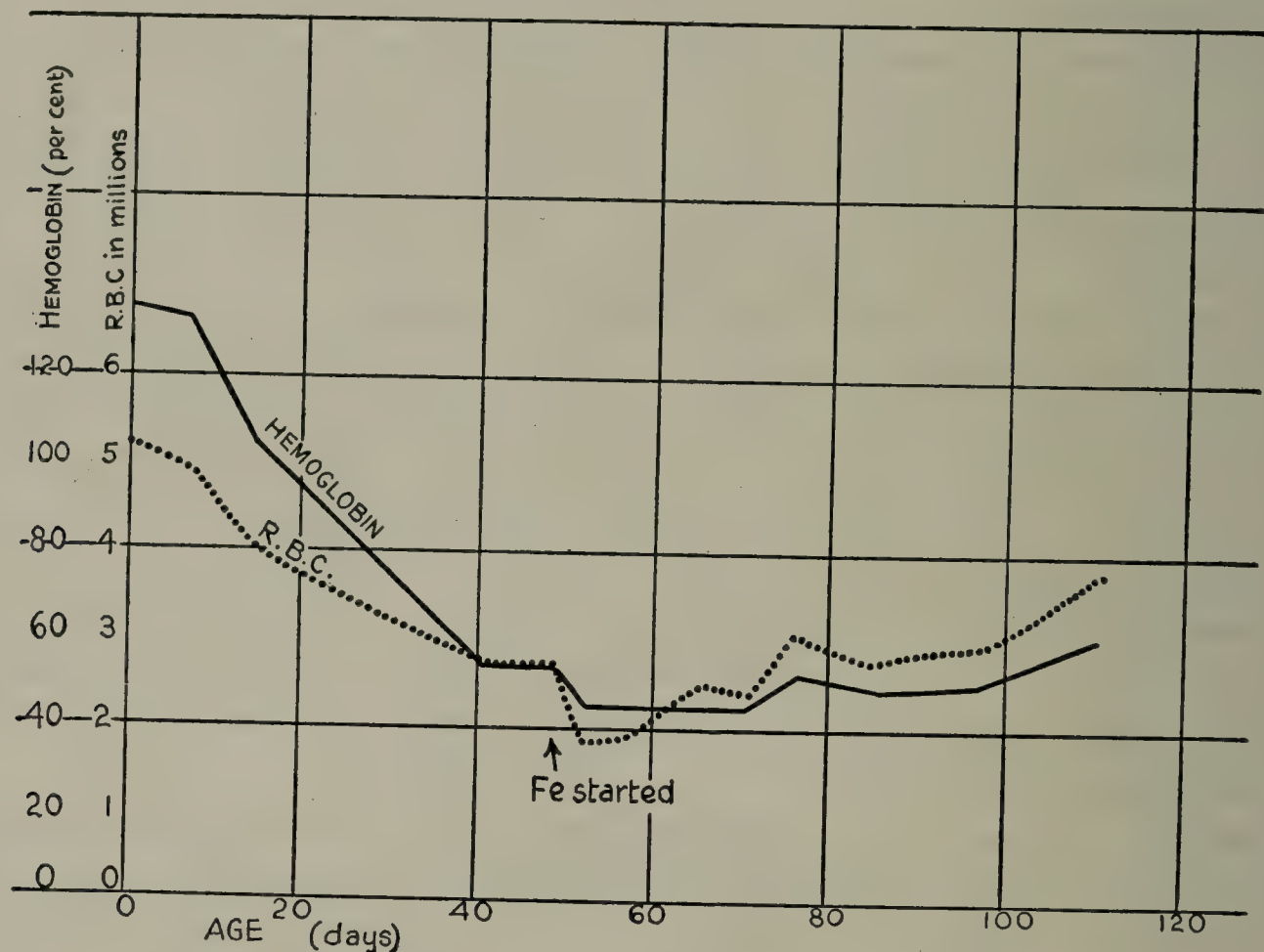


FIG. 78.—COURSE OF ANEMIA IN A PREMATURE INFANT, SHOWING FAILURE TO RESPOND TO IRON DURING THE EARLY MONTHS.

can be satisfactorily treated without the agency of pyrrol derivatives speaks against their being of etiological importance.

Lack of iron appears to be the most important cause of nutritional anemia. Our experience has been that iron alone will regularly produce a cure, although improvement is sometimes greatly hastened by the addition of copper. Inorganic iron appears to be more effective than iron in organic combination; probably organic iron compounds must be broken down before the iron can be assimilated.

The importance of copper in hemoglobin formation was first demonstrated by Hart and his coworkers in 1928, and has since been abundantly confirmed. Copper itself probably does not enter the hemoglobin molecule, but small amounts of copper appear to be necessary before iron can be used for hemoglobin synthesis. The copper requirements of the growing infant are not accurately known, but milk is relatively poor in this element as well as in iron, and it is quite possible that in some instances a deficiency of copper may be a contributory, if not the determining cause of nutritional anemia.

In treatment, general hygienic measures should not be forgotten. Transfusions



may be indicated in severe cases. The specific treatment consists in the administration of large doses of inorganic iron and small amounts of copper. Iron does more than supply an essential building material for hemoglobin. It also stimulates the bone marrow. After a latent period of a few days there occurs a marked rise in the reticulocytes, which is usually followed by a rise in hemoglobin and in the red cells. The accompanying illustration shows the effect of copper given as a supplement to iron in such a case. Copper given alone has no influence; even in the presence of iron it does not seem to stimulate the bone marrow, for it has little

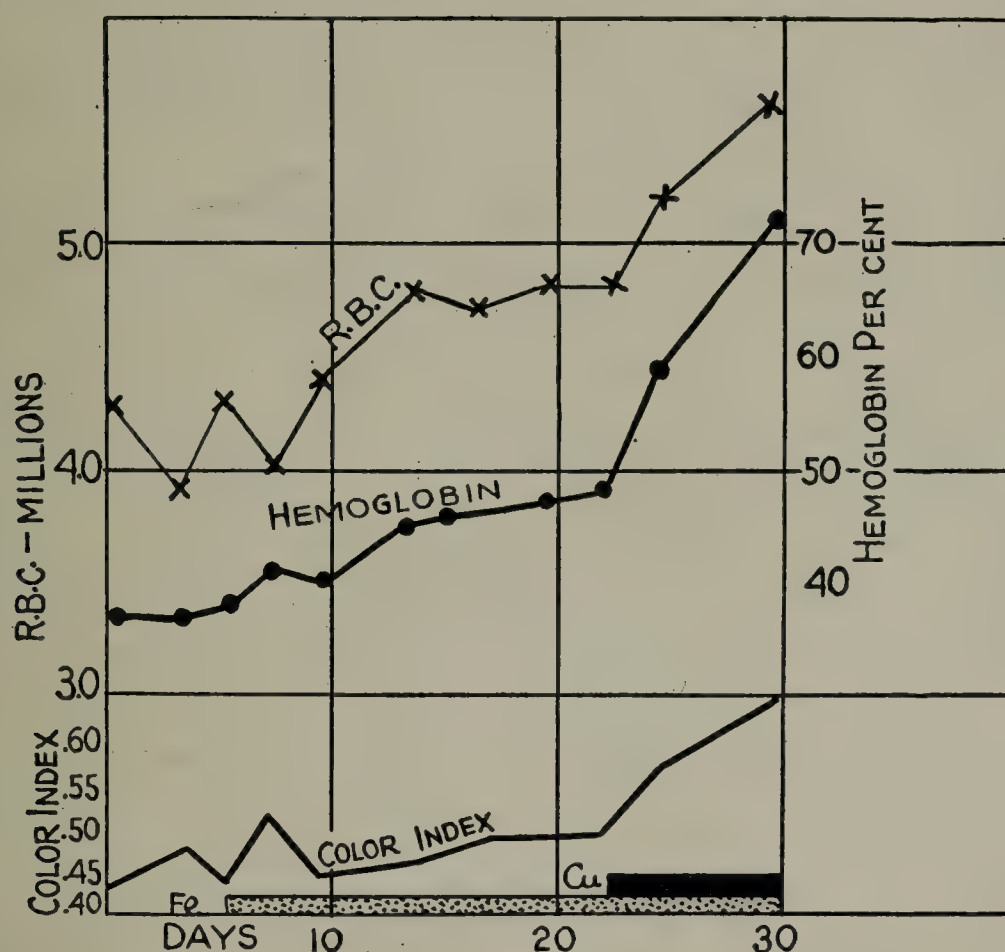


FIG. 79.—NUTRITIONAL ANEMIA, SHOWING INFLUENCE OF COPPER IN RAISING THE COLOR INDEX.

effect on the reticulocytes or the red cells. However, the addition of copper to iron causes a marked increase in the hemoglobin and in the color index.

The response to iron and copper therapy is usually prompt. Within three or four weeks the hemoglobin has usually reached the normal value, unless some complicating factor such as an infection is present. In most circumstances iron and copper therapy need only be temporary. As soon as it is feasible the infant should be put on a mixed diet and the need for administering these elements will then disappear.

The following report illustrates a typical case of nutritional anemia:

S.P. (H.L.H. 62250) was admitted to the hospital at the age of eleven months because of undernutrition and poor appetite. He had been a normal infant at birth, had been nursed three months, but since then had received only whole milk and sugar, with the exception of a small amount of cod liver oil. He had suffered from frequent upper respiratory infections.

On admission he weighed 12½ pounds (5.5 kilograms). He was pale and listless and could sit only with difficulty. Examination revealed a palpable spleen and liver with slight enlargement of the heart and a blowing systolic murmur. The blood showed R.B.C. 2,200,000; hemoglobin 45 per cent; W.B.C. 13,650. Differential: polymorphonuclears 51 per cent; lymphocytes 46 per cent; monocytes 3 per cent. The red cells



showed marked anisocytosis and poikilocytosis; no young red or white cells were observed; the platelets were apparently normal. A count showed 0.6 per cent reticulocytes.

A few days after admission the patient acquired otitis media which subsided after a day or two. Therapy consisted in the addition of iron and subsequently of copper as well to a standard milk formula. The accompanying chart illustrates the reticulocyte response to iron therapy, followed by a rise in hemoglobin. Increasing the dose of iron to twice the usual amount (see p. 558) had little influence, but the addition of copper caused a further rise in hemoglobin.

*Goat's Milk Anemia.*—In 1916 Scheltema described in Holland a severe anemia developing in infants fed for a prolonged period on goat's milk; since then there have been many reports on this condition in the European literature. The anemia

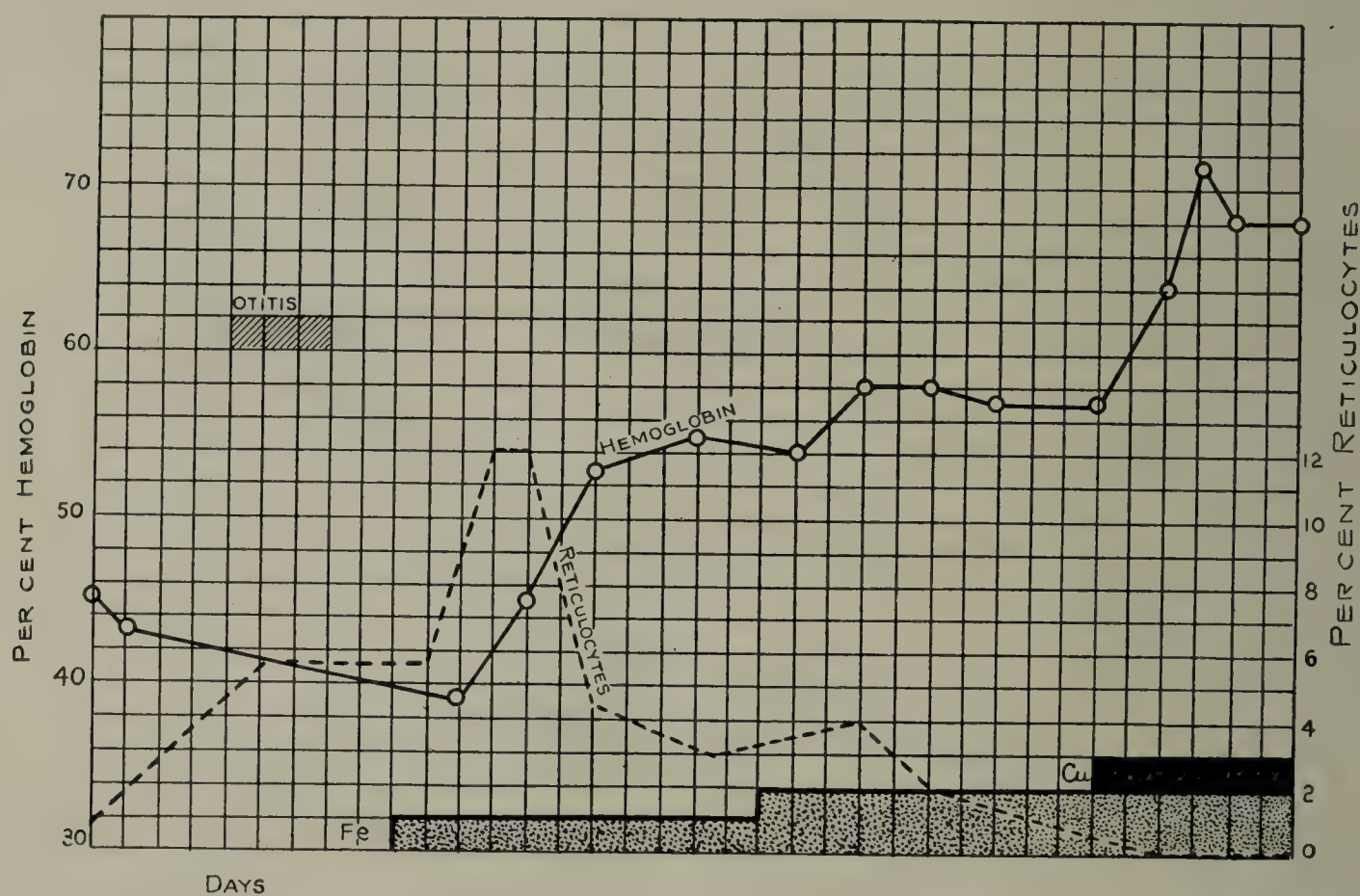


FIG. 80.—NUTRITIONAL ANEMIA TREATED WITH IRON AND COPPER.

is usually hypoplastic, but in some instances the von Jaksch syndrome has been observed with a moderate increase in blood destruction. Many authors have maintained that the anemia is due to some harmful property of goat's milk fat; this fat is peculiar in that it contains considerable quantities of caproic, caprylic and capric acids. Baar, however, has shown that goat's milk anemia can be regularly cured merely by increasing the quantity of goat's milk fed, from which it would appear that goat's milk anemia, like cow's milk anemia, is due to a dietary deficiency. Comparative analyses of the copper and iron content of goat's milk have failed to show that the quantity of these minerals is appreciably different from that in cow's milk. However, as Gorter points out, goat's milk is usually given fresh, whereas cow's milk is usually subjected to handling and heating in metal containers. Heating in a copper or iron vessel may double or even triple the copper or iron content of milk; hence the infant fed on cow's milk is likely to receive more of at least one of these minerals than the infant fed on goat's milk. Goat's milk anemia is rare in this country; we have had no personal experience with it.



**Anemia from Infections.**—Infections play a very important part in the anemias of early life; the hematopoietic system of the child seems to be much more susceptible than that of the adult. The reaction of the individual is most variable; one child weathers an infection, perhaps a severe one, without becoming anemic, while another develops a severe anemia with great rapidity. Even when anemia develops there is little uniformity in the type of response. The anemia may be hemolytic, or there may be a hypoplastic picture; sometimes suppression of the blood platelets with thrombopenic purpura is the most striking manifestation. All sorts of mixed types are met with. As an illustration of the variable response to a single infection Blackfan cites the case of two brothers who simultaneously developed a hemolytic streptococcus infection. One child developed no anemia but responded with a hyperleukocytosis in which immature white cells were conspicuous; he recovered uneventfully. The second child developed a severe aplastic anemia with leukopenia and thrombocytopenic purpura, the condition terminating fatally.

Almost any infection can give rise to anemia, but some do so with greater frequency than others. Among the acute infections, pneumonia because of its frequency plays an important part in producing anemia. Of the chronic infections, syphilis, malaria and pyelonephritis deserve especial mention; sepsis and chronic suppurative processes of all kinds—empyema, osteomyelitis, etc.—are often responsible for anemia. In older children focal infections, rheumatic fever and nephritis are of particular importance. Tuberculosis rarely causes a severe anemia, although a moderate reduction of the red cells and hemoglobin is not uncommon. Curiously enough, infections of the gastro-intestinal tract—dysentery, typhoid, paratyphoid—are not often the cause of anemia.

With recovery from infection the anemia may disappear promptly or a more or less prolonged *postinfectious anemia* may continue. Such postinfectious anemias are usually attributed to injury to the bone marrow which outlasts other evidences of the infection. That this may not be the only difficulty is indicated by the observations of Josephs, who has observed negative iron balances during acute infections. When the diet provides only a small excess of iron above the requirements for hemoglobin maintenance, such a loss of iron is not readily repaired and iron deficiency may be the factor delaying recovery from anemia. In such cases a prompt response may follow the administration of iron or iron with copper. It is thus apparent that an infection may serve as the starting point for a nutritional anemia.

The treatment of anemias associated with infection is most unsatisfactory in the acute stage while the infection is active. Repeated transfusions are indicated if the anemia is severe; they are of particular value in hypoplastic cases with diminished platelets. During convalescence and with subacute or chronic infections iron and copper or iron and liver should be given. One can form no accurate opinion from clinical data as to when the bone marrow will break away from the depressing action of an infection, hence it is advisable to have these substances available to take full advantage of the propitious moment when it arrives. By this means recovery from postinfectious anemia can, in many instances, be greatly hastened.



**Other Etiological Factors.**—Among the less frequent causes of anemia in children may be mentioned hemorrhage and hemorrhagic affections. Pachymeningitis hemorrhagica, scurvy, and hemorrhagic disease of the newly born are conditions that belong particularly to early life. Parasites are important causes of anemia in certain localities. Neoplasms can produce a severe anemia but are rare. Of the poisons, lead is by far the most important in childhood; mercury and potassium

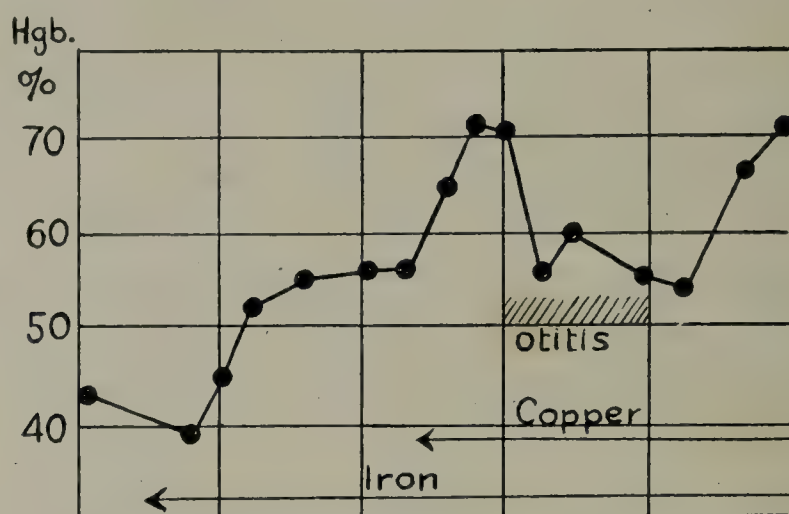


FIG. 81.—ANEMIA; FAILURE OF RESPONSE TO IRON AND COPPER DURING INFECTION.

Patient nine months old; no known previous infection, nor any abnormality in the neonatal period likely to have produced the anemia. Iron alone caused a rapid rise in hemoglobin from 40 to 55 per cent, but had no further effect even when the dose was doubled. Copper, given in addition to iron, promptly effected a rise to 70 per cent. Following this there was a period in which the infant had an infection, with drop in hemoglobin to 55 per cent, where it remained until the infection was over; subsequently, a second rapid rise to about 70 per cent. The interval between vertical lines represents two weeks.

chlorate poisoning are less frequent. A severe aplastic anemia may result from overdosage with x-rays or radium.

The part played by hygienic factors in the production of anemia is a disputed one. Older works stress absence of fresh air and sunlight, and overcrowding in institutions as flagrant causes of anemia. It is probable that infections and diet have much to do with the prevalence of anemia in institutions, but it is quite possible that sunlight exerts some influence on the hematopoietic system. Welch attributes the disappearance of chlorosis in recent years to modern fashions in the dress of young women. Scientific observations in regard to the effects of light on the blood have given conflicting results. The most recent work of Laurens indicates that ultraviolet rays may cause an increase in red cells, but exert little influence on hemoglobin formation.

### PRIMARY ANEMIAS

Leukemias and idiopathic purpura are described elsewhere, although there is some justification for grouping them with the primary anemias. It is doubtful whether true pernicious anemia ever occurs in children. Castle informs us that the youngest case of which he has a record, where the diagnosis was beyond question, was in a girl thirteen years old. Cases have been reported in infants in which there was a hemolytic anemia with diminished gastric acidity and a blood picture typical of pernicious anemia and in some instances even a favorable response to liver extract. However, in none of these instances have such characteristic find-



ings as the changes in the tongue, achylia uninfluenced by histamine, or cord lesions been reported. A reticulocyte response following liver extract is not an infallible criterion, for such extracts may contain considerable amounts of iron and copper.

**Anemia of the Newly Born.**—A low level of hemoglobin during the first days of life is uncommon. Even when the mother is very anemic or suffering from a severe blood disease, the infant's hemoglobin and red cells are usually normal or at the most only slightly below the normal average figures. Prenatal causes may, however, give rise to anemia. Instances have been described of congenital anemia following excessive radiation of the mother with radium or x-rays. Lead poisoning in the mother may give rise to anemia at birth; in such instances lead has been recovered from the organs of the child. Postnatal causes—birth infections, hemorrhages and hemorrhagic disease of the newly born—may cause the rapid development of anemia.

In contrast to these secondary anemias there is a group of cases in which anemia of the newly born develops without apparent cause. The hemoglobin at birth is usually below 100 per cent and falls rapidly. The infant is pale and does not develop icterus neonatorum; vomiting may be conspicuous. Examination of the blood shows little or no evidence of regeneration. In fatal cases the erythroblastic marrow has been found aplastic.

These idiopathic anemias of the newly born are apparently caused by some constitutional anomaly which results in failure of blood formation. A familial incidence has been observed by Lewis and by Diamond. There are two distinct types. In one, which includes the great majority of these cases, the condition is only temporary; after a period of three or four weeks active hematopoiesis begins and there is an uneventful recovery. Transfusions may be necessary during the early critical weeks. In the second group, which is rare, the *congenital aplastic anemia* persists indefinitely. We have recently seen one such case (H.L.H. 60353) in a boy four years of age who had been kept alive by blood transfusions given every three to six weeks since birth. By this means his hemoglobin had been maintained between 20 and 60 per cent. He was somewhat underdeveloped physically. The blood picture was entirely normal except for reduction in red cells and hemoglobin and complete absence of reticulocytes; apparently the patient himself produced little or no hemoglobin. Attempts to stimulate the bone marrow were futile. Studies of the urobilin output revealed no excessive blood destruction when the hemoglobin was between 20 and 60 per cent. The patient could be transfused again and again from the same donor without any reaction. However, when attempts were made by massive transfusions to maintain his hemoglobin at normal levels, it was found impossible to do this, for increased blood destruction would then develop.

**Primary Hypoplastic Anemia.**—In some cases the hypoplastic blood picture appears to set in after the neonatal period. Anemia develops, often with great rapidity, and on examination the blood is found to contain little or no evidence of formation of new erythrocytes. The reticulocyte count is low—less than 0.1 per cent; often no reticulocytes at all can be demonstrated. In some cases the granular leukocytes or the platelets or both are simultaneously diminished, and when the picture is complicated by thrombopenia hemorrhagic manifestations may occur. In



the few studies of bone marrow that have been made, no satisfactory morphological explanation has been found. The patient may be helped by repeated transfusions, but no lasting improvement in the fundamental condition is likely to occur.

**Primary Aplastic Anemia.**—This condition, first described by Ehrlich, is rare in children. The disease may develop at any age and occurs in individuals previously healthy. The onset is insidious with symptoms of anemia. The course is acute or subacute; it progresses without remissions and terminates fatally within a few months or a year. The blood picture shows a severe anemia with a normal color index; young red cells are inconspicuous or absent. Usually there is a leukopenia with relative lymphocytosis; granulocytes may comprise less than 10 or 15 per cent of the white cells; eosinophils may be wanting altogether. Some immature leukocytes may occur, but, as a rule, most of the white cells are normal. The platelets become diminished and hemorrhagic manifestations occur. The bone marrow is not uniformly affected; in some instances erythropoiesis alone is suppressed. Evidences of hemolysis are absent in the early stages; later on, particularly after internal hemorrhages, there may be urobilinuria. Enlargement of the spleen, if it occurs, is only moderate. The lymph nodes are not hypertrophied. Ulcerative lesions of the buccal mucosa—so often associated with agranulocytic conditions—may develop. An intercurrent infection usually terminates the picture.

The findings at autopsy show a marked atrophy of the hematopoietic marrow, which is largely replaced by fat. Hemosiderosis may be present. A very striking finding is the presence of enormous masses of bacteria growing in profusion in the tissues unchecked by any leukocytes or other evidences of inflammation.

The cause of primary aplastic anemia is obscure. It may well be due to some unknown agent which injures the bone marrow. The disease can in no way be distinguished from secondary anemias caused by poisoning from benzol, arsphenamine, nirvanol, or overdosage with x-rays. Acute aleukemic leukemia causes a similar clinical and hematological picture; in this latter condition enlargement of the lymph glands or spleen and abnormalities of the white cells may make a diagnosis possible, but there are instances in which during life it is impossible to say which condition is present. Indeed some writers regard primary aplastic anemias as instances of aleukemic leukemia in which a hyperplastic marrow has eventually become exhausted.

The distinction between primary aplastic anemia and aleukemic leukemia is of academic interest only; the prognosis is equally bad in both. It is, however, of practical importance to distinguish these cases from idiopathic purpura, where the prognosis is often good. In purpura hemorrhages precede the anemia, whereas they occur late in aplastic anemia. Evidences of red cell regeneration are to be found in purpura following a hemorrhage.

**Hemolytic Jaundice (Primary Hemolytic Anemia).**—This condition is characterized by icterus of hemolytic origin, anemia, enlargement of the spleen and abnormalities of the red blood cells, notably a decreased resistance to hemolysis by hypotonic salt solutions. Two forms are recognized—a congenital familial form (*Chauffard-Minkowski type*) and an acquired form (*Hayem-Widal type*).

Congenital hemolytic jaundice is usually hereditary; the disease can sometimes be traced for three or four generations. Occasionally, however, it appears in sev-



eral brothers or sisters, the parents being unaffected. It is transmitted by both parents alike; not all the descendants are affected and the offspring of unaffected members escape entirely. A latent form of the disease has been noted in affected families, with increased fragility of the red blood cells but no symptoms. Such individuals may transmit the disease. The condition may remain latent throughout life or symptoms may develop at any time. In some cases thought to be acquired hemolytic jaundice, a careful examination of the family has revealed latent cases indicating that the condition was in reality familial.

The symptoms are much the same in the familial and the sporadic form. Jaundice may be noted in early infancy or may develop at any time, even after puberty; it may develop insidiously or appear suddenly. Itching of the skin and telangiectases do not occur. The intensity of the icterus is variable, but when once developed there is no tendency for the disease to revert to the latent stage. The icterus is not obstructive. There is an increased bilirubinemia with an indirect Van den Bergh reaction. Bile acids are not increased in the blood and do not appear in the urine. The stools are darker than normal and contain large amounts of urobilin, more than in any other condition except sickle cell anemia. The urine contains urobilin in excess but no bilirubin.

The liver is normal or slightly enlarged. The spleen is regularly and often extremely enlarged. The blood shows an anemia, usually of moderate degree, but sometimes severe. Both red cells and hemoglobin are proportionately reduced, the color index remaining not far from 1. There are evidences of greatly increased hematopoietic activity; although basophilia and nucleated red cells are present in moderate numbers the reticulocyte count is extraordinarily high. Reticulocytes often constitute 20 per cent, sometimes even 40 or 50 per cent of the total red cells, in contrast to the normal value of 1 per cent. The red cells tend to be more globular than disk-shaped; they are smaller in diameter but larger in volume as determined by hematocrit. The decreased resistance to hemolysis by hypotonic salt solutions is the most characteristic feature of the disease; the results do not differ appreciably when whole blood or washed cells are used. Normally hemolysis begins with a concentration of 0.42 to 0.38 per cent NaCl and is complete between 0.36 and 0.32 per cent. In hemolytic jaundice hemolysis usually commences at a concentration about 0.48 per cent and may begin at 0.60 or 0.70 per cent. It is usually complete between 0.55 and 0.40 per cent. The white cells show nothing remarkable.

Although cases of hemolytic jaundice often go for years exhibiting no symptoms other than jaundice, splenomegaly and a moderate anemia, *hemolytic crises* are likely to occur with severe symptoms. These may be precipitated by infections or by very insignificant events—emotional disturbances, exposure to cold, a railway journey, etc. The onset of such a crisis is often abrupt with fever and a chill; there is a rapid increase in the icterus and a precipitous fall in the hemoglobin and red cells; the spleen enlarges and the liver may do so. There may be attacks of abdominal colic, attributed to perisplenitis. Associated with these crises there is a great increase in the urobilin excretion in the stools and urine. The duration of the attack may be a few days or several weeks. In severe cases nervous symptoms may occur—convulsions and coma—even death, but in most instances there is un-



eventful recovery. Increased blood regeneration appears as the symptoms subside; at such times there may be erythroblastosis and an increase in the platelets and in the leukocytes with many early forms; the blood picture may for a time simulate leukemia. Hemorrhagic manifestations are rarely met with in hemolytic jaundice with the exception of epistaxis; in some cases this occurs frequently.

The diagnosis should offer little difficulty. With a positive family history of jaundice it should be suspected at once. Sporadic cases can be distinguished from other anemias with icterus and splenomegaly by the fragility test. With the single exception of poisoning with toluylenediamine, increased fragility is seen only in hemolytic jaundice. Occasionally the results of the fragility test are inconclusive and further laboratory evidence may be sought. Beckmann described a "provocative fragility test" which served to make the diagnosis in several instances. Massage of the spleen or irradiation of the spleen with x-rays or ultraviolet rays served to bring out latent fragility. The observations have been confirmed by several German authors. Fragility can sometimes be demonstrated by means of hemolytic agents other than hypotonic saline. Van den Bergh described a case in which fragility to hypotonic saline appeared only after exposure of the red cells to  $\text{CO}_2$ . All fragility tests should be controlled by observations on normal subjects.

Hemolytic jaundice is not ordinarily a dangerous disease. Growth and development are usually unimpaired, and affected persons may live to an advanced age. Chauffard's statement that "these patients are more icteric than sick" holds true for the great majority. Only when there is interference with the general health or frequent hemolytic crises is treatment necessary. Splenectomy is the only effective measure. It should not be performed during a hemolytic crisis. In almost all instances it causes marked improvement, and frequently it is followed by symptomatic cure. Hemolytic phenomena rarely disappear entirely, but there is usually a marked reduction in the bilirubinemia and the urobilin output. The resistance of the red cells sometimes returns to normal or shows some improvement, but in many instances there is no change in the resistance even though the operation is followed by the most dramatic clinical improvement. A prolonged erythroblastosis may follow splenectomy.

The cause of hemolytic jaundice is still disputed. Postmortem findings have shown nothing to distinguish this condition from other hemolytic anemias. The spleen is greatly congested; it contains many phagocytic cells laden with hemosiderin; there may be evidence of perisplenitis. There may be hemosiderosis of the liver, kidneys and other organs and hyperplasia of the erythroblastic marrow. Most observers regard the anomaly of the red cells as the primary defect, rather than some dysfunction of the spleen itself. It appears probable that the increased phagocytosis of red cells which undoubtedly occurs in the spleen is due to the greater ease with which pathological red cells are destroyed.

*Atypical Forms.*—The familial form of hemolytic jaundice is unquestionably the most clear-cut entity in this general group, but even here there are great variations in the degree of icterus, anemia and splenomegaly present. There are cases of "compensated anemia" in which the increased blood destruction is cared for by sufficient regeneration so that almost no anemia and no subjective symptoms appear. Icterus and bilirubinemia, however, are present. These are to be distinguished from



latent cases where fragility alone can be demonstrated but there is no evidence of unusual blood destruction.

The sporadic cases are even less uniform, and show certain differences from the familial form. They are likely to begin suddenly and to be more severe. The increased fragility is rarely as marked as in the familial cases. The small, globular red cells are not found. Some authors like Naegeli believe that these cases have a totally different etiology. Widal and his collaborators have noted auto-agglutination of the red cells in their cases of acquired hemolytic jaundice, a phenomenon which is not characteristic of the congenital form.

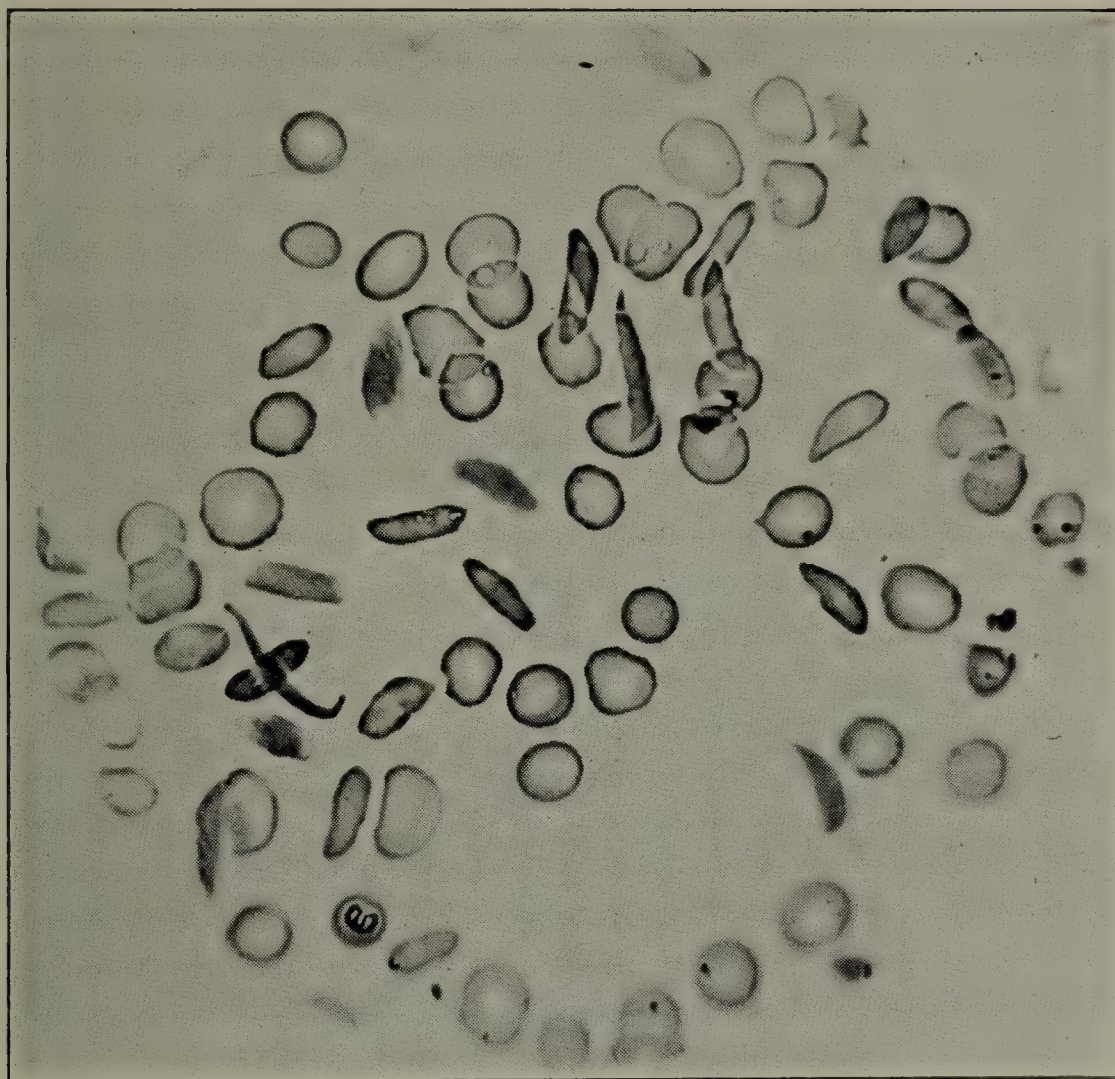


FIG. 82.—SICKLE CELL ANEMIA.

Hemolytic anemias are occasionally met with which exhibit all the characteristics of hemolytic jaundice except the increased fragility of the red blood cells. Both benign and malignant types have been observed. Whether these should be regarded as atypical forms of hemolytic jaundice is an open question.

**Sickle Cell Anemia.**—This disease presents many analogies to congenital hemolytic jaundice. There is a congenital anomaly of the red blood cells, transmitted to the offspring. In some instances this defect gives rise to a hemolytic anemia with exacerbations and remissions, whereas in other cases the condition remains latent.

Sickle cell anemia and its latent form (*latent sickling* or *meniscocytosis*) are found exclusively, or almost exclusively, in the colored race. The condition is very common. Between 5 and 8 per cent of American Negroes show latent sickling, but only a small proportion of these develop anemia. The characteristic appearance of the red cells may be found in active cases immediately after withdrawal from the



body, or it may develop on standing. In latent cases the change develops only on standing. In order to detect the condition a fresh wet preparation is sealed with a coverslip and petroleum jelly. The cells gradually change their shape, becoming elongated with pointed ends drawn out into filamentous processes; they tend to be curved, resembling the blade of a sickle. Sausage-shaped cells with rounded ends are not characteristic. The change in shape takes place rapidly or slowly but in six to twenty-four hours from 25 to 90 per cent of the cells have assumed these bizarre forms. The peculiarity resides in the cells; the transformation takes place when washed cells are suspended in saline. Sickling is accelerated by heat and by lack of oxygen; it can be produced rapidly by saturating a red cell suspension with  $\text{CO}_2$ , and by means of oxygen the reaction can sometimes be reversed.

The active form of the disease may appear at any age. It has been observed as early as three months and after thirty years of age; usually, however, the onset is between the first and tenth years. The disease may be ushered in by a febrile attack, after which the hemolytic anemia persists with exacerbations. The onset may be insidious, the first symptoms to attract attention being pallor, weakness and an icteric tint to the sclerae. The symptoms may be mild and little anemia develop even during exacerbations. In general, however, the disease is more severe than congenital hemolytic jaundice; when the condition has lasted a long time it is rare to find normal growth and development. The most prominent symptoms are weakness, dyspnea and palpitation; in the most severe cases these patients are completely incapacitated. Pains in the muscles and joints of the extremities are common; there may be attacks of abdominal pain with nausea. These phenomena are usually met with during exacerbations, and may be accompanied by low grade fever, night-sweats and more pronounced cardiac manifestations. The heart may be enlarged and exhibit a systolic murmur. A faulty diagnosis of rheumatic endocarditis is often made. Chronic ulcers of the legs are found in adults but are rare in children. On examination the patient shows a greenish icteric tint to the sclerae. The liver is often enlarged; splenomegaly is the rule in children, especially during exacerbations; after puberty splenomegaly is unusual.

The blood shows an anemia of varying severity; the color index tends to remain high. Anisocytosis and poikilocytosis are present. Stippled and nucleated red cells are found in moderate numbers, but reticulocytes are greatly increased and may constitute 20 to 30 per cent of the total red cells. Platelets and white cells are likely to be somewhat increased and young forms are often apparent. Erythrophagocytosis by mononuclear cells is often visible in fresh blood preparations. Sydenstricker states that he has never failed to find it. In addition to the sickling phenomenon the red cells show other peculiarities. The resistance span toward hypotonic saline is increased; although hemolysis begins at approximately the normal level (0.45 per cent) it is rarely complete until a dilution of 0.24 to 0.20 per cent has been reached (the normal level for complete hemolysis being 0.36 to 0.32 per cent). The blood shows an increased bilirubin content with an indirect Van den Bergh reaction. The urine contains no bilirubin, but there is a markedly increased excretion of urobilin in both urine and stools.

It is questionable whether patients with active sickle cell anemia return spontaneously to the latent stage. Some reason for believing that the condition may



become latent if the patients reach adult life is afforded by the observations of Sydenstricker, who obtained a history of characteristic symptoms in childhood in some latent adult cases. The prognosis for active childhood cases is, however, distinctly unfavorable. Splenectomy does not have the favorable effects noted in hemolytic jaundice; only in cases where the spleen is greatly enlarged has there been any striking improvement. The condition can be combated only by transfusions. The patient with sickle cell anemia seems to be particularly susceptible to infections; these are frequent and lead to an exacerbation of the anemia. Death may occur during a hemolytic crisis. Cirrhosis of the liver has been noted as a complication; we have seen one such instance. Josephs observed a child with hypertension and fixed specific gravity of the urine which cleared up after a transfusion.

The latent cases are symptom-free, and the prognosis is favorable, for only a small proportion develop active manifestations. However, the line between active and latent cases is not an absolutely sharp one. Some of these individuals exhibit increased blood destruction which is compensated so that no anemia develops. Such latent cases seem to show an unusual tendency to react to infections with a hemolytic anemia.

The pathogenesis of sickle cell anemia is obscure. It may be assumed that some abnormality of the red cells renders them more susceptible to hemolysis in the body, even though *in vitro* tests fail to show increased fragility, but it is difficult to explain why individuals with latent sickling fail to show hemolysis. Pathological observations have failed to clear up the question. An abnormality of the spleen appears to be a very constant feature in both latent and active cases. According to Rich there is a malformation of the sinuses about the malpighian bodies leading to the formation of pools of blood partially or completely surrounding the malpighian bodies. The capillaries of the malpighian body show an abnormal development. These vascular anomalies may cause the escape of blood into the splenic pulp. Active cases of sickle cell anemia show in addition the lesions of any hemolytic anemia. There is hemosiderosis of the organs, chiefly in the cells of the reticulo-endothelial system. There may be metaplastic blood formation. The bone marrow is hyperplastic, and in some instances this has led to changes in the bones similar to those described in erythroblastic anemia.

**Primary Erythroblastic Anemia.**—This entity has been separated by Cooley from the large group of anemias showing the von Jaksch syndrome. It appears to be a true primary anemia based on some congenital defect. The disease is familial, occurring only in children of the Mediterranean races—especially Greeks, Italians and Syrians. It is characterized by a slowly progressing anemia resistant to all forms of treatment, marked changes in the bones, and a characteristic mongoloid facial expression. The blood shows the von Jaksch picture; an extraordinarily prolonged erythroblastic response follows splenectomy.

The disease begins insidiously in infancy, symptoms being usually noted before the second year. The attention may be attracted by pallor of the skin with a slight icteric tint, by a protruding abdomen caused by the great enlargement of the spleen or by weakness. These symptoms gradually increase and may be followed by manifestations of cardiac insufficiency. Periods of unexplained fever may occur. The physical development may be greatly retarded.



When the condition is well developed the face is found to have a characteristic mongoloid expression (Fig. 83); the cheek bones are prominent, the nose is short with a depressed bridge, there may be epicanthus and mild exophthalmos. The skull shows prominent frontal and parietal bosses; the sutures may be depressed in contrast. The liver and lymph nodes may be enlarged; great enlargement of the spleen is constant. Frequently the heart is hypertrophied and shows a systolic murmur.

Roentgen-ray examination of the bones shows very striking changes. The long bones show osteoporosis, the trabeculae standing out clearly. The cortex is thin and

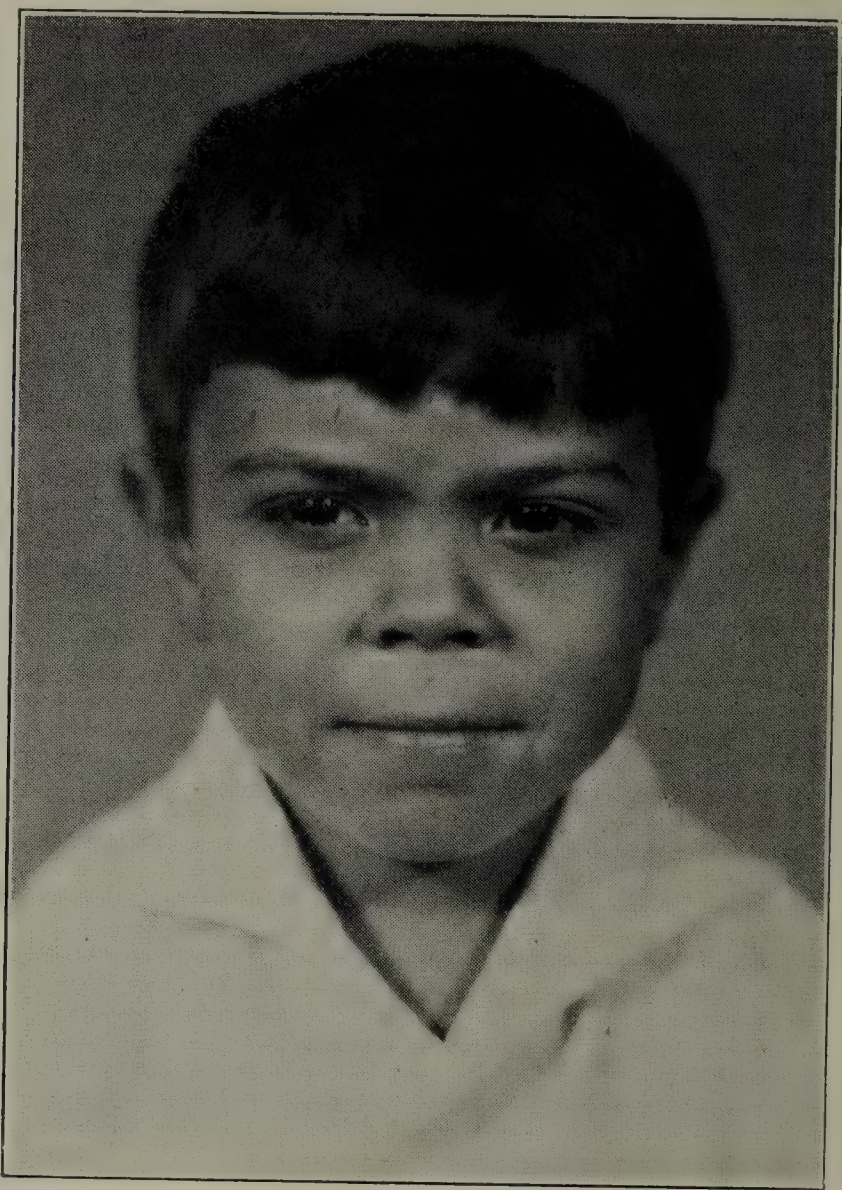


FIG. 83.—PRIMARY ERYTHROBLASTIC ANEMIA: CHARACTERISTIC MONGOLOID FACIES.

the medullary cavity correspondingly widened. The whole bone is increased in width and transverse lines are generally conspicuous. The skull shows thickening with rarefaction; in extreme cases the trabeculae connecting the outer and inner tables appear as radiating spicules, a condition which Baty and others have likened to "hair standing on end" (Fig. 87).

The blood shows the typical von Jaksch picture—a low color index, marked aniso- and poikilocytosis, many immature red cells, especially erythroblasts, increased platelets and a granulocyte leukocytosis<sup>1</sup> in which immature cells are found. Reticulocytes constitute from 5 to 20 per cent of the total red cells; they do not reach the high values seen in sickle cell anemia and hemolytic jaundice. It would

<sup>1</sup> In the counting chamber nucleated red cells appear as white cells; a correction must be made by a differential count on the stained smear if the white cells are to be accurately determined.



appear that less blood regeneration is present in erythroblastic anemia but that the type of red cell produced is a more immature one. Fragility tests have shown prolongation of the resistance span at both ends. Baty, Blackfan and Diamond give as average figures 0.54 to 0.50 per cent saline for the onset of hemolysis (normal 0.45) and 0.30 to 0.20 for complete hemolysis (normal 0.34). Cooley and Lee state



FIG. 84.—PRIMARY ERYTHROBLASTIC ANEMIA.

that the predominating red cell in erythroblastic anemia has specific characteristics: it is unusually large and has an uneven distribution of hemoglobin; with special stains they claim to have demonstrated an abnormality of the stroma; these findings they have met with in no other condition except sickle cell anemia.

Increased blood destruction occurs in erythroblastic anemia but is not as marked as in hemolytic jaundice or sickle cell anemia. The urobilin output in the stool is



FIG. 85.—ROENTGENOGRAM OF FOREARM IN PRIMARY ERYTHROBLASTIC ANEMIA.  
Characteristic widening of the medulla with cortical atrophy.

moderately increased, and urobilin may or may not be found in the urine. The icterus index and bilirubin content of the blood are high, the Van den Bergh reaction being indirect.

The course of the disease is slowly progressive, but these patients may survive into adult life. Baty and his coworkers believe that the earlier the onset the more





FIG. 86.—ROENTGENOGRAM OF HAND IN PRIMARY ERYTHROBLASTIC ANEMIA.  
Typical alteration of bone structure.

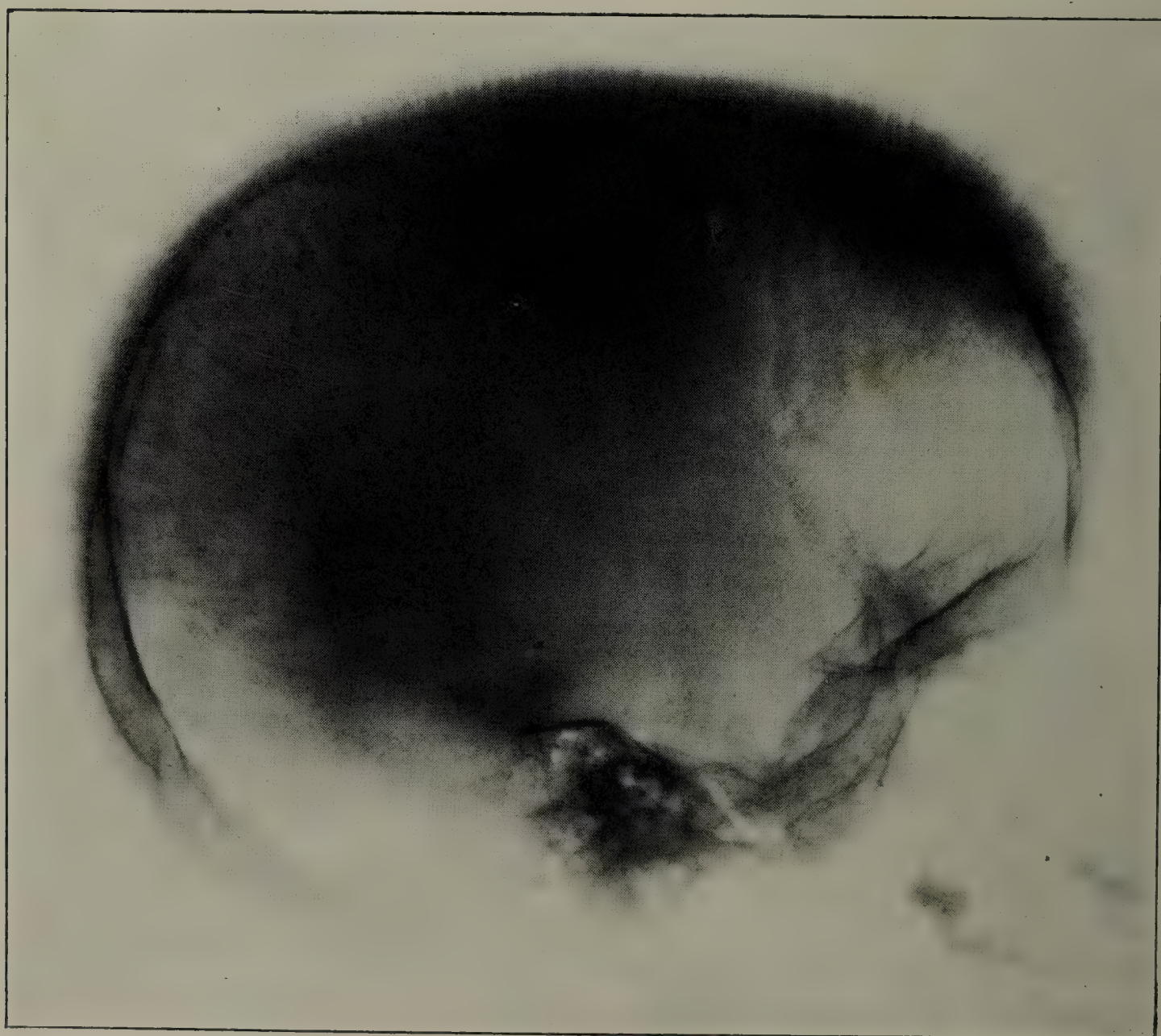


FIG. 87.—ROENTGENOGRAM OF SKULL IN PRIMARY ERYTHROBLASTIC ANEMIA.  
Radial arrangement of bone spicules in calvarium.



rapid the course is likely to be. Remissions and exacerbations are less conspicuous than in hemolytic jaundice or sickle cell anemia, but increased hemolysis may be observed during infections. At times there are seen periods of hyperpyrexia without other evidence of infection which are accompanied by increased hemolysis and an exacerbation of symptoms. Death usually results from infections. With the exception of transfusions no treatment is of value. Splenectomy causes an extraordinarily

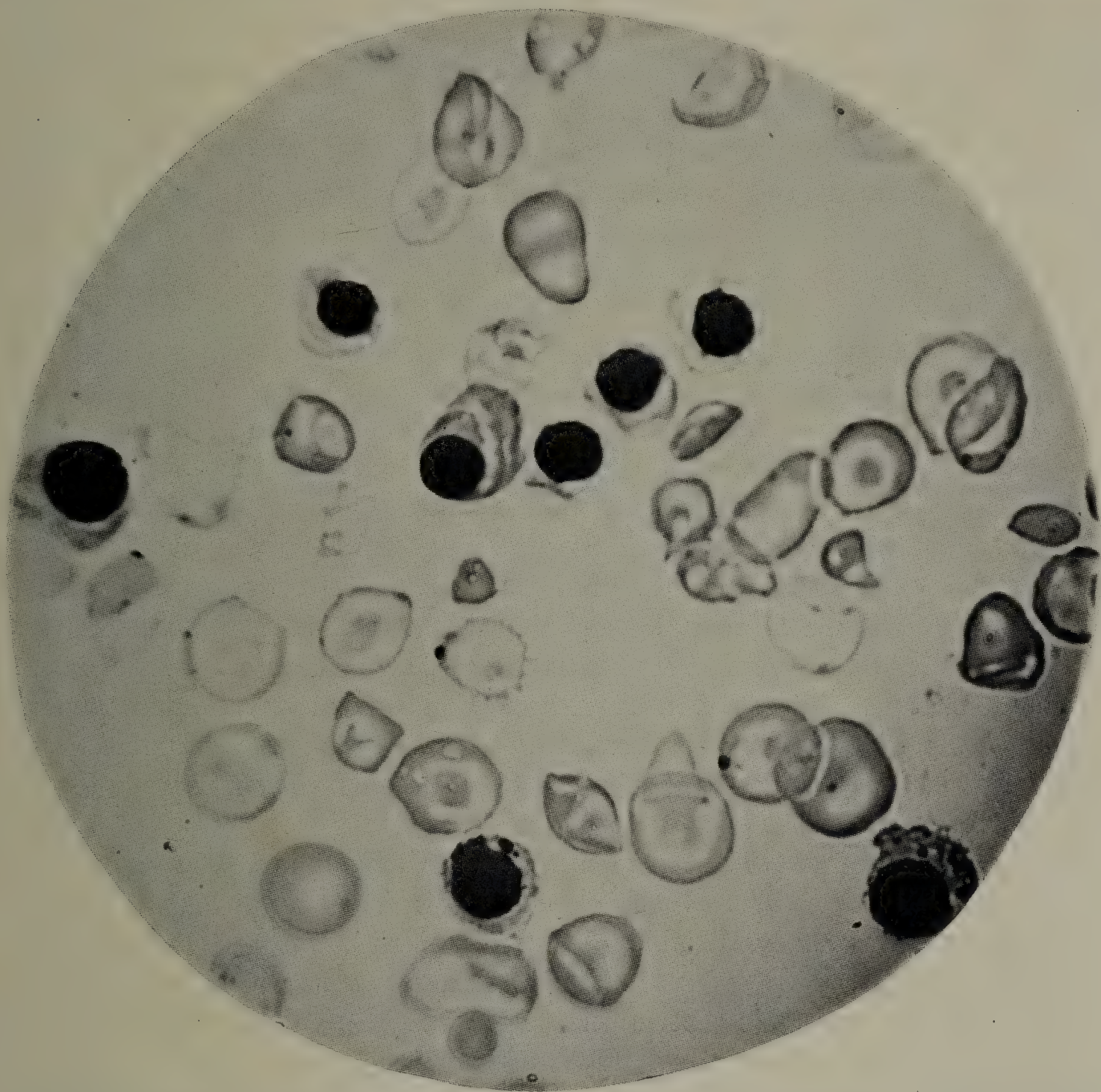


FIG. 88.—PRIMARY ERYTHROBLASTIC ANEMIA, SHOWING NORMOBLASTIC INCREASE AFTER SPLENECTOMY.

prolonged erythroblastic crisis, the nucleated red cells increasing rapidly and remaining high for months and even years; sometimes they constitute from 5 to 10 per cent of the total red cells. However, there is little or no improvement in the anemia.

A number of pathological observations have been made. The most striking hematopoiesis is found in the bone marrow, spleen, liver and lymph nodes. The bone marrow is deep red and islands of immature red cells are present everywhere; there is absence of fat, and the cortex of the bone is encroached on by the hyperplastic marrow. The conspicuous features in the spleen are the extreme erythro-



poiesis, the degree of atrophy of the malpighian bodies and the presence of numerous eosinophils. As in other hemolytic anemias, hemosiderosis is found and there may be fibrosis, particularly in cases of long standing.

**Banti's Disease—Splenic Anemia.**—These rather unsatisfactory terms are applied to a clinical condition which can sometimes be sharply differentiated. It is characterized by a slowly progressive anemia with splenomegaly, leukopenia and a tendency to gastric hemorrhages. After a period of years cirrhosis of the liver develops. There is little tendency to spontaneous recovery; the condition is usually terminated by hemorrhage or intercurrent disease before the development of evidences of hepatic insufficiency or obstruction.

The pathological findings are quite uniform, although there are no especially distinguishing features. The spleen shows increased fibrosis involving the capsule and trabeculae. In the early stages the follicles may be enlarged; later, as the fibrosis becomes more extensive, they are small and infrequent. The sinuses are congested. Hemorrhages and infarcts may be found. Hemosiderosis is not conspicuous. The liver is normal in the early stages; late in the disease there is a periportal cirrhosis. Changes in the splenic and portal veins are inconstantly found.

The condition is met with at all ages, even as early as the second year; it is, however, rare in young children. The onset is insidious. Symptoms of anemia may be the first thing to attract attention; in other instances it may be abdominal enlargement due to the large spleen, or hematemesis. The anemia is of the hypoplastic type with a low color index and few young red cells. The platelets are normal or diminished. Most of the time there is leukopenia with a relative lymphocytosis, but a transitory leukocytosis may follow hemorrhage. Most observers have found no distinct peculiarities of the red cells, although an increased resistance has been reported. As a rule, evidence of increased blood destruction is wanting. On examination of the patient a large, hard spleen is felt; the enlargement may be extreme. Sometimes there are attacks of pain, due to perisplenitis.

Hemorrhage from gastric or esophageal varices may occur early or only after the cirrhosis has developed. The blood may be vomited or may appear in the stools. Bleeding elsewhere is unusual, and can be attributed to low platelets.

The duration of the precirrhotic stage is variable; it may be a year or two, or more than fifteen years. It is characterized by remissions and exacerbations. With the development of cirrhosis there may be ascites and more or less icterus with urobilinuria. In the early stages splenectomy is often followed by great benefit, if not cure. After cirrhosis has developed it accomplishes nothing.

There has been much discussion as to whether Banti's disease is a real entity. In all probability a number of causes can produce this picture, hence it may more properly be spoken of as Banti's syndrome. These cases can as a rule be differentiated from primary cirrhosis of the liver by the absence of liver pathology in the early stages. Banti regarded it as a primary intoxication of the spleen. Unquestionably the Banti syndrome can be caused by various chemical poisons and by chronic infections, notably syphilis, but such obvious etiological factors are often wanting. Wallgren has recently called attention to a group of cases in which venous obstruction in the portal or splenic vein produced a clinical picture resembling Banti's disease. *Obstruction to the splenic vein* causes congestion and enlargement



of the spleen with the early development of gastric and esophageal varices. In such cases hematemesis is usually the first symptom. Following a hemorrhage the spleen diminishes in size and may not be palpable, but with the cessation of bleeding it soon enlarges again. In long-standing cases with extreme fibrosis this change in the size of the spleen with hemorrhage does not occur. Transient attacks of ascites may develop in these cases, and do not necessarily signify hepatic involvement; they may result from a local peritonitis caused by splenic infarction.

When there is *obstruction to the portal vein* ascites is more pronounced and portal cirrhosis of the liver may develop. It thus appears that a vascular lesion involving the splenic and extending into the portal vein will explain the development of early splenomegaly with gastric hemorrhage and subsequent cirrhosis of the liver. In many instances the obstruction shows no tendency to spread to the portal vein. The causes of such venous stasis are numerous; there may be inflammatory or degenerative lesions or malformations of the vessels themselves, or the vessels may be distorted by pathological processes outside, such as adhesions. In a number of cases of Banti's disease and of the syndrome described by Wallgren as obstruction to the splenic vein, no vascular lesions have been found and one is forced to assume that a functional obstruction exists.

Without a history of gastric hemorrhage, the diagnosis of early Banti's disease or of obstruction to the splenic vein should be made only by exclusion. The various types of primary hemolytic anemia that may be associated with an enlarged spleen should be ruled out, also secondary anemias due to infection, particularly syphilis. Malaria and leishmaniasis must be considered in certain localities. The latter condition can be diagnosed by splenic puncture, as can Gaucher's disease and lipoid histiocytosis (Niemann-Pick disease). The characteristics of these affections are described elsewhere. When there is gastric hemorrhage, particularly in the absence of bleeding elsewhere, the diagnosis is less difficult; however, the various hemorrhagic conditions—particularly leukemia and idiopathic purpura—must be ruled out. The alteration in the size of the spleen following hemorrhage is a particularly helpful sign.

Rosenthal has classified these cases into two groups on the basis of the level of the blood platelets before and after splenectomy. When the platelets are decidedly subnormal before operation, they show only a temporary postoperative rise, and splenectomy produces favorable results; whereas if the platelets are normal or only slightly subnormal before operation, this may produce a permanent thrombocytopenia and there is greater danger of repeated thromboses. In this latter group splenectomy is not advisable. However, further observations are needed in order to confirm this distinction. On the whole splenectomy appears to be indicated if there are gastric varices without evidence of cirrhosis of the liver.

## DIAGNOSIS OF ANEMIA

The presence of anemia is rarely overlooked, if it is at all severe. Occasionally symptoms of circulatory insufficiency dominate the picture and lead to a mistaken diagnosis of rheumatic heart disease.

To determine the cause of anemia is another matter. Sometimes this is obvious enough, but often it is obscure. A study of the nature of the process and a careful



search for the cause may be required. The therapeutic response may give the clue to the condition.

In any obscure anemia one should first attempt to find out whether the process is essentially hemolytic or hypoplastic (anemias due to loss of blood are, for the moment, not considered). In hemolytic anemias the color index usually remains high, but this is not an invariable rule. The reticulocyte count, which is the best measure of regeneration, may give indirect information as to the degree of blood destruction; increased blood formation in the face of an unimproving anemia implies excessive blood destruction. Exceptions to this occur in leukemia and in early congenital syphilis—conditions in which the red marrow may be entirely replaced by pathological tissue; active extramedullary blood formation takes place with large numbers of reticulocytes in the blood, while total erythrocyte production is below normal. Accurate information in regard to blood destruction can be obtained only by studying the pigment metabolism. An icteric tint to the sclerae and urobilinuria may be due either to liver disease or to increased hemolysis. If there is a high indirect Van den Bergh reaction in the blood, or urobilinuria without bile in the urine, one may assume that there is hemolysis. However, it requires a great increase in blood destruction before bilirubinemia or urobilinuria develop; moderate increases in hemolysis can only be determined by quantitative studies of the output of urobilin in the stools, a cumbersome procedure at best.

*Hemolytic anemias* may be classified as (1) those in which compensation fails to occur; (2) those in which there is compensatory regeneration without evidence of bone marrow strain, and (3) those in which compensatory regeneration is accompanied by marked evidence of bone marrow strain, a variety of abnormal and young forms being thrown out. In the first group the anemia tends to be progressive. Overwhelming infections and chemical poisons may cause this picture; it may be due to parasites like *dibothryocephalus latus*; acute leukemia and primary aplastic anemia belong in this group although aplasia is usually a more important factor than hemolysis in these. Idiopathic purpuras may also be classified here. In the second group there is compensatory regeneration of red cells as shown by an increase in reticulocytes but little evidence of bone marrow strain; nucleated red cells and other young forms are inconspicuous. Only two conditions need here be considered: hemolytic jaundice and sickle cell anemia. These are readily distinguished by racial incidence and the peculiarities of the red cells. In the third group, where the bone marrow responds by producing abnormal and especially immature forms, infections, parasites and poisons must again be thought of. Marked basophilic stippling is characteristic of lead poisoning. The chronic leukemias should be mentioned. Secondary anemias of the von Jaksch type—often due to a combination of nutritional and infectious factors—form an important part of this group and, lastly, primary erythroblastic anemia.

*Hypoplastic anemias* often have a low color index; a low reticulocyte count is, however, the most reliable indication of defective blood formation. A persistent anemia without evidence of increased blood destruction implies defective blood formation. Pure hypoplastic anemias (without excessive hemolysis) may be classified as: (1) those with diminished bone marrow activity without evidence of strain, and (2) those in which decreased blood formation is accompanied by strain, abnor-



mal young forms being conspicuous. In the first group belong "physiological anemia," anemia of prematurity, the congenital aplastic anemias and most cases of Banti's disease. In the second group are found most instances of nutritional anemia. Infections, lues in particular, often produce this picture; poisons, parasites and neoplasms are infrequent causes.

The difficulties involved in ascertaining the etiology of anemias in childhood have already been mentioned—the fact that many factors may play a part in an individual case, and the fact that infections can produce such a variety of blood responses. The separation of anemias into hemolytic and hypoplastic types is, however, of some practical importance, for it may indicate what form of specific therapy is likely to be successful—measures to check hemolysis or to stimulate the bone marrow.

## TREATMENT OF ANEMIA

**General Measures.**—These are often quite as essential as any specific treatment that can be given. Additional *rest* and limitation of exercise are particularly important for older children. *Fresh air* and *sunlight* may well be of some value. There are clinical reports which indicate great improvement after radiation with sunlight or ultraviolet lamps, but the observations are few and not well controlled. The recent animal experiments of Laurens indicate that irradiation may increase the red cell count but has little influence on the hemoglobin. Every effort should be made to clear up infections and to protect the child against new ones; *infections* are by far the most frequent cause of anemia in childhood. The *diet* should be a balanced and appetizing one containing an abundance of all the vitamins. There is little evidence that vitamin deficiencies cause anemia, except in the case of scurvy, but every effort should be made to maintain the nutrition at an optimum. Infants over six months of age should receive a mixed diet, in which liver may well be included.

*Transfusion* can be regarded as both a general and a specific measure. Not only does it replace lost blood, but it also serves as a stimulant to the bone marrow, and by increasing the resistance to infection it may break the vicious circle of infection and defective utilization of blood-forming food elements which tends to perpetuate anemia. Transfusion is imperative in all severe anemias; if the hemoglobin is 30 per cent or less, or if symptoms of cardiac insufficiency are present, no delay is permissible. In the presence of acute hemorrhage or purpura, transfusion should be given at once. Transfusion is a most effective specific in anemias associated with infection, nutritional anemias and in many instances of purpura. In the last named condition there may be a prompt rise in the platelets, due entirely to new platelet formation, for all the platelets are agglutinated and useless in the transfused blood when citrated blood is used.

*Bone marrow stimulants* are likely to be effective only in hypoplastic conditions. If blood regeneration is already conspicuous little can be expected. However, in certain anemias with a low color index and with high reticulocyte counts, stimulants that act upon hemoglobin synthesis rather than on red cell formation may hasten recovery; for example, the addition of copper to a nutritional anemia showing a reticulocyte response to iron may greatly augment the hemoglobin rise. Transfu-



sion as a hematopoietic stimulant has been mentioned above. *Iron* is a valuable specific, and should be tried in any anemia where defective blood formation is suspected. It is most effective in nutritional anemias. It does far more than supply an essential component of hemoglobin; it increases red cell formation and also causes hemoglobin synthesis. A latent period of one to ten days may pass before the beneficial effects are observed; the first effect is a rise in the reticulocytes, which is followed promptly by an increase in the hemoglobin. Iron is most conveniently given in the form of a 10 per cent solution of iron and ammonium citrate; 2 c.c. of this solution per kilogram of body weight (1 c.c. per pound) may be given daily, most conveniently in the milk. This dose can be continued indefinitely.

*Copper* has no effect on red cell formation. In the absence of iron it is valueless in anemia, but when given in addition to iron it may cause a striking rise in hemoglobin. The red cells are little affected, so that there is usually an increase in the color index. Copper is most effective in nutritional anemias, but may be of value in other types of aplastic or hypoplastic anemia. It is most conveniently given in form of a  $\frac{1}{2}$  per cent solution of crystalline copper sulphate added to milk. The dosage recommended by Josephs is 1 c.c. of the copper sulphate solution per kilogram of body weight per day (0.5 c.c. per lb.). It may be divided into three or four doses. Occasionally this amount will cause diarrhea or vomiting; in such instances one may start with one-third or one-quarter of the dose mentioned and increase it gradually. Copper therapy should not be continued indefinitely. Its beneficial effects, when they are observed, appear promptly. If there is no effect within ten days it may be discontinued, and even when there is a marked response, this rarely continues for more than three or four weeks. There would seem to be no indication for continuing it more than six weeks at a time.

*Liver* and *liver extract* may cause definite benefit in anemias of various types. The specific response seen in pernicious anemia has also been described in anemias caused by parasites. In many other instances of secondary anemia striking responses have followed the use of liver or liver extract, but it is highly doubtful that these are due to the specific active principle so effective in pernicious anemia. Liver is rich both in iron and copper, and it may well be that these elements are responsible for the beneficial results rather than some nitrogenous constituent. Liver may be given even to young infants; 5 grams a day of puréed liver should be given per kilogram of the patient's weight.

*Arsenic* in the form of Fowler's solution was formerly much used as a stimulant for blood formation. There is no clear evidence that it exercises a beneficial effect in the anemias of childhood.

When faced with an anemia due to defective blood formation one should first try the effect of iron with copper and with liver; should this be ineffective, small, frequent transfusions may be tried.

The only specific measure for hemolytic anemias (aside from eliminating infections) is splenectomy. This should be undertaken in chronic cases and then only as a last resort, for there is a definite operative risk. It has proved of the greatest benefit in cases of hemolytic jaundice. In sickle cell anemia the results are variable; improvement appears to have followed only when the splenomegaly was extreme. In erythroblastic anemia it is of doubtful value. In early Banti's disease,



particularly in those cases with early hematemesis, splenectomy may cause a complete cure; if the disease has lasted for some time, less is to be expected. Splenectomy in idiopathic purpura, in Gaucher's disease and allied conditions is considered elsewhere.

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## CHAPTER LXII

### LEUKEMIA

Leukemia is a disease characterized by extensive proliferation of leukopoietic tissue throughout the body. Two distinct forms are met with—*lymphoid leukemia*, in which the lymphadenoid tissue is affected, and *myeloid leukemia*, in which the proliferation involves the cells of the myeloid series. Although mixed types and monocytic leukemias have been described, the existence of these latter entities is still doubtful. In chronic forms of leukemia there is usually a great increase in the number of white cells in the circulating blood. In acute forms there may be no such increase (aleukemic leukemia) and there is often leukopenia.

Leukemia is a rare disease in childhood, but both forms are met with, even in early infancy. The greater frequency in males holds good for children. The cause of the disease is entirely obscure; in some respects it resembles neoplasms, and in others it suggests an infectious etiology. Leukemia of fowls has been shown to be caused by a filtrable agent, but there is no such evidence regarding the human disease. One instance is recorded in which a transfusion was performed with leukemic blood; the recipient failed to contract the disease.

### LYMPHOID LEUKEMIA

**Pathology.**—The lesions do not differ greatly in the acute and chronic cases. There is hyperplasia of the lymphadenoid tissue over the entire body. The nodes are enlarged and there is a great increase in lymphoid cells, which fill the sinuses and may nearly replace the whole glandular structure; as a rule, however, the architecture of the nodes is at first fairly well retained. The spleen is similarly affected, the Malpighian bodies being greatly hypertrophied. The myeloid tissue of the bone marrow is to a large extent replaced by lymphoid tissue. The liver is often enlarged and contains infiltrations of lymphoid tissue. These are found to some extent in other organs. Lymphoid chloromatous tumors have been observed in children. The evidences of a terminal infection are often found at autopsy.

**Symptoms.**—In *acute lymphatic leukemia*, which in our experience is the most common form of leukemia in early life, the symptoms are so severe and the progress so rapid as to suggest an acute infection. The onset may be abrupt with severe symptoms—fever, vomiting, a chill, general and articular pains and great prostration; or it may be more gradual with only local symptoms for several weeks. The swelling of the external lymph nodes may be the first thing noticed; this is most marked usually in the cervical region, but the axillary, inguinal, femoral and epitrochlears may also be involved. The individual nodes may be no larger than an almond, but often reach the size of a walnut. At times, however, they may be only slightly enlarged, and often not at all. There is no redness and seldom tenderness. The tonsils and the adenoid tissue of the pharynx may greatly increase in size.



We have seen three cases in which there was an extensive leukemic infiltration of the parotid, submaxillary and lacrimal glands. This gave rise to the so-called Mikulicz syndrome. The spleen is usually much enlarged. It may extend into the pelvis and across the median line. It is often painful and very tender. The liver is apt to be enlarged. Hemorrhages often occur. These may be subcutaneous in the form of small petechiae or larger purpuric areas, or there may be bleeding from the nose, the bowels, the bladder, or blood may be vomited. Often there are retinal hemorrhages. The mouth often is the seat of lesions that resemble scurvy. In fact, these symptoms may dominate the clinical picture. The gums are much swollen and bleed easily; there may be sloughing in the gums, tonsils or buccal mucous membrane. The general symptoms at this stage are usually severe. The temperature is nearly always somewhat elevated and it may be as high as 103° or 104° F.; there are marked dyspnea and great muscular weakness; the pulse is rapid and feeble and the loss of weight usually marked.

The blood picture varies greatly in different cases and at different stages of the disease. In the early stages there is usually an aleukemic picture; the white cells are not increased and often there is a leukopenia. In acute cases the disease may progress to a fatal termination without ever showing a leukocytosis. In the subacute cases which last for weeks or months, a leukocytosis of 25,000 to 100,000 may develop, but even here a terminal leukopenia may occur. The most constant feature of the blood is a relative increase in lymphocytes, which form as a rule from 90 to 98 per cent of the white cells. A large proportion of these cells are pathological; many of them are unduly large, others show irregularities in the shape and staining properties of the nucleus. Fragility of these lymphoid cells is striking and a stained smear usually shows many "smudges." The red cells are uniformly reduced to from 1,000,000 to 3,000,000 and the hemoglobin to 20 or 30 per cent or less. The bleeding time is increased but the clotting time is usually unaffected. A striking and constant feature is the reduction in the number of platelets; a diagnosis of acute lymphatic leukemia should not be made if these are present in normal number. We have seen one boy two years of age with severe anemia with 98 per cent of his cells lymphocytes but with few pathological lymphocytes and a normal number of platelets. After transfusion he made an uneventful recovery.

The course of this disease is usually rapid. It may last only two or three weeks and rarely more than two or three months. Death may be due to hemorrhage, to circulatory failure, or to some acute intercurrent infection.

Other cases run a less acute course and may be marked by irregular and prolonged attacks of fever which in some cases may be high and last for months, but with few other symptoms except enlargement of the lymphatic glands. The blood picture varies much from time to time, the constant feature being the high proportion of lymphocytes, many of which are immature, and a moderate degree of anemia. The total leukocyte count may be low for a long period but a marked relative increase in the lymphocytes is a constant feature. The chronic form of lymphatic leukemia does not differ greatly from that in the adult but in our experience is very uncommon in children.



## MYELOID LEUKEMIA

**Pathology.**—In this form of the disease the pathological changes are chiefly in the spleen and bone marrow. The spleen is usually enormously enlarged, sometimes filling half the abdominal cavity. In the early stage it is firm and smooth, later it may become rough and adherent in places. On section it is reddish gray and finely granular. In the late stages it may be uniform in appearance, the trabeculae being no longer apparent. The bone marrow is firmer and redder than normal. The liver, which is regularly enlarged, usually shows no striking alteration in the gross.

Microscopically the changes consist in the presence of myelocytes (neutrophilic, eosinophilic and basophilic) in enormous numbers. These cells together with myeloblasts are found in the blood vessels everywhere, but especially in the bone marrow, where they are outside as well as inside the capillaries and where they largely replace the erythroblastic tissue. The splenic venules and spaces are closely packed with these cells and in the liver the capillaries are distended with masses of them, so much so that many strands of liver cells may be greatly compressed or entirely disappear. The lymph nodes are not affected except that their blood vessels are full of the abnormal cells. Myeloid chloromas may occur.

**Symptoms.**—In acute myeloid leukemia the symptoms and the blood findings often resemble acute lymphatic leukemia so closely that the disease is usually mistaken for it. Although myelocytes may be present in the blood in moderate numbers, the typical cell in these acute cases is the myeloblast, and unless oxidase stains or other special stains are used, these cells cannot be distinguished from lymphocytes. Occasionally, even with special staining methods, some doubt remains and the true nature of the leukemia is revealed only at autopsy. There can be no doubt that acute myeloblastic leukemia is much more common than is usually supposed.

Chronic myeloid leukemia is very rare before the third year, although typical instances have been reported by Malmberg even in the first year of life. The onset is usually insidious. A sudden and alarming hemorrhage is sometimes the first thing to call attention to the serious condition. In other cases there are only the symptoms of general weakness and pallor. A splenic tumor often is the first thing noticed. In the early part of the disease the usual symptoms of anemia are present—digestive disturbances, shortness of breath, weak and rapid pulse. Hemorrhages may occur as an early or late symptom; they are most frequently from the nose, but severe hemorrhages may occur from the stomach, the mouth, the intestines; or there may be ecchymoses or petechiae in the skin. The enlargement of the spleen may be so great as to form an abdominal tumor which attracts the attention even of the parents. The swelling of the liver is not so marked. The lymph nodes are enlarged only to a moderate degree, and in many cases this symptom is absent altogether. They are painless, movable, and usually several groups are affected.

The late symptoms are dropsy of the feet or general anasarca, hemorrhages, diarrhea, headaches, general weakness, and attacks of syncope. Fever is quite constant in the late stages of the disease, and the temperature may be from 101° to 103° F. The urine may contain albumin and casts. Vision is sometimes disturbed by the formation of leukemic plaques or hemorrhages in the retina. It is rare that



there are any symptoms referable to the bones, although expansion and tenderness of the flat bones have been observed.

Aleukemic blood pictures are not usually found in chronic forms of the disease except as a result of treatment or as a terminal phenomenon. The number of leukocytes is usually markedly increased and may be from 100,000 to 500,000 or even more. Nearly all of this increase is in the cells of the granular series. The number of polymorphonuclear leukocytes is greatly increased, although their proportion is diminished. Myelocytes are present, usually in large numbers, and many myeloblasts too are found. A characteristic feature which is helpful in distinguishing chronic myeloid leukemia from other forms of hyperleukocytosis is the presence of numerous eosinophile and basophile myelocytes; mature eosinophils and basophils are likely to be found in increased proportion also. In contrast to the acute leukemias the blood platelets are greatly increased in the chronic form.

### DIAGNOSIS OF LEUKEMIAS

Acute leukemias must be distinguished from infections which may give similar constitutional symptoms. The buccal symptoms may suggest scurvy. A rapid general enlargement of the external lymph nodes is very suggestive of leukemia, but the diagnosis rests upon the demonstration of a large proportion of abnormal lymphocytes or young myeloid forms in the blood. Sepsis and occasionally syphilis may give blood pictures similar to acute leukemia. The greatest difficulty is to distinguish between acute lymphoid leukemia and that group of benign conditions characterized by fever, sore throat, general glandular swelling and the presence of numerous immature lymphocytes in the blood, which goes by the name of glandular fever or infectious mononucleosis. The blood picture is sometimes indistinguishable from that of acute lymphoid leukemia, but as a rule it is uncommon to find cells as immature as those found in leukemia. Glandular fever occurs in epidemics, but sporadic cases are not very infrequent. In some cases only the course of the disease may reveal its benign character. The relation between acute aleukemic leukemia and primary aplastic anemia has been discussed elsewhere.

Chronic lymphoid leukemia is rarely difficult to recognize from the blood picture. Chronic myeloid leukemia must be distinguished from infections with hyperleukocytosis, as has been pointed out above.

### TREATMENT OF LEUKEMIAS

Acute leukemias run their course, uninfluenced by any treatment. Transfusion may be of benefit, but the improvement is very transitory. Most cases succumb in the course of a few weeks, either to hemorrhage, circulatory failure or an intercurrent infection.

Chronic forms of leukemia with marked increase in the leukocytes are more susceptible to treatment. Although the fatal outcome cannot be prevented it can sometimes be put off for several years. The chronic myeloid leukemias show the most favorable response. Radium or x-ray treatment will cause the white cells to diminish, with an accompanying diminution in the size of the spleen and lymph nodes and relief from symptoms. The leukocytes may continue to fall for some days or weeks after a treatment is given so that one must proceed very cautiously



when the count falls below 50,000, otherwise a serious leukopenia may develop. Sooner or later the effect wears off and the patient begins to relapse. A repetition of the treatment produces less and less effect until there is no response whatever. A similar reduction in the leukocytes can be brought about by other agents. Benzol was formerly much used. Arsenic in the form of Fowler's solution has been employed with striking success. It produces effects similar to those of x-rays and radium. At the present time it would appear desirable to use arsenic until it no longer produces a response and then to employ x-rays and radium. The usual method of administration is to begin with 4 drops of Fowler's solution three times a day for a child of eight years, and to increase the daily quantity by 1 drop every two or three days until 8 drops are given at each dose. One should stop short of this if digestion is disturbed, or there is puffiness of the face or albumin in the urine. Arsenic should always be given after meals, and largely diluted. The possibility of arsenical poisoning should be remembered, although it is rare. We have known of several cases in which multiple neuritis developed after a few weeks' administration of the drug.

In chronic lymphoid leukemias, arsenic and benzol are ineffective agents. Some benefit may be brought about by radium and x-rays but the results are not as constant nor as striking as with the chronic myeloid leukemias. Few chronic lymphoid leukemias survive more than a year, whereas in the chronic myeloid cases life may be prolonged for from two to six years or even more with appropriate treatment.

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## CHAPTER LXIII

### HEMOPHILIA

Hemophilia is a hereditary disease, characterized by a tendency to prolonged bleeding from trivial causes. Persons so affected are known as "bleeders."

**Etiology.**—The hereditary tendency is very marked and has sometimes been traced through seven or eight generations. It is distinctly unusual to encounter a case with a negative family history of the disease. The hemophilic trait is sex-linked. The disease appears only in males, but is transmitted only by female "conductors," who do not themselves suffer from it. From the union of a male hemophilic with a normal female, all female children will be conductors, whereas all male children will escape entirely and are incapable of transmitting the disease further. The union of a normal male with a female conductor may produce normal or hemophilic males and normal females or conductors. It is theoretically possible for hemophilia to appear in females as the result of the union of a hemophilic male with a conductor; unproven but suggestive examples of this have been reported.

**Pathogenesis.**—The hemorrhages in hemophilia are caused by an impaired coagulability of the blood; the clotting time is greatly delayed, as first shown by A. E. Wright. Normally, venous blood coagulates in from three to six minutes, whereas in hemophilia the blood usually requires more than twenty minutes and often several hours to coagulate. Howell has shown that the delay in coagulation is due to a deficiency of prothrombin, and Minot and Lee demonstrated a qualitative deficiency of the platelets. Platelets from hemophilic blood did not promote the clotting of normal blood as well as did platelets from normal blood. Since platelets produce not only prothrombin but also thromboplastic substance, the defect is a double one.

Kubányi has recently reported the interesting finding that all hemophiliacs studied by him belong to the same blood group (Group A, Landsteiner; II, Moss or Jansky).

**Symptoms.**—Hemophilia rarely manifests itself in early infancy. It bears no relation to hemorrhagic disease of the newly born. Symptoms are usually noted by the latter part of the first year. The discovery of the disease is usually quite accidental. A very minor cut may cause a most severe hemorrhage; a slight contusion may result in a large hematoma. The eruption of teeth may cause considerable hemorrhage. Fatal results have often followed minor surgical operations which were undertaken without a knowledge of the patient's condition.

Attacks of spontaneous hemorrhage occur in many of these cases. The bleeding may occur from any mucous membrane, but the nose is by far the most frequent site. Cutaneous hemorrhages are infrequent. A common site both for spontaneous and traumatic hemorrhage is the knee joint. This is a serious complication, for repeated hemorrhages here often lead to permanent deformity. We have seen a spon-



tanous retroperitoneal hemorrhage in a hemophilic patient giving a clinical picture closely resembling appendicitis with abscess formation. The hemorrhagic tendency seems in certain patients to undergo periodic fluctuations which are unexplained.

Hemophilia manifests itself in all degrees of severity. The statistics of Grandidier indicate the seriousness of the condition: among 152 boys, one-half died before the age of seven. A few instances are reported in which the disease was outgrown in later life, but such an outcome is most unusual and not to be expected.

The condition rarely offers any difficulty in diagnosis. It is readily distinguished from purpura by the prolonged clotting time, the normal platelet count, the infrequency of skin hemorrhages and the family history.

**Treatment.**—The indications at the time of bleeding are to arrest the hemorrhage by ordinary surgical procedures—especially compression. Transfusion should be employed when the hemorrhage cannot otherwise be controlled; it has a very marked but transient effect. In convalescence after a hemorrhage a liberal diet and iron should be given.

The preventive treatment is far from satisfactory. It is not practicable to give transfusions at sufficiently frequent intervals to protect the patient. Various treatments have been recommended. Howell obtained some promising results from subcutaneous injections of tissue extracts and of cephalin; his results in feeding such material over a prolonged period were not striking. Protein sensitization has been tried by several observers, but the results are by no means uniform. The same may be said for estrogenic substances, snake venom, ascorbic acid, large doses of vitamin D, and many other remedies recommended from time to time. Recently, Eley, Green and McKhann have reported promising results with the use of a placental extract, a form of therapy which it is still too early to evaluate. All patients who are bleeders must be carefully protected against any factor that might excite hemorrhage.

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## CHAPTER LXIV

### PURPURA

The term purpura is used to designate a tendency to spontaneous hemorrhages which may be cutaneous or subcutaneous, from the mucous membranes, or internal. Purpura is sometimes known as *morbus maculosus* or *Werlhof's disease*. It occurs in many forms and in association with a great variety of other conditions, a fact which makes classification difficult.

Purpuras were originally classified according to their clinical manifestations, the term *purpura simplex* being applied to cases in which the hemorrhages were limited to the skin, *purpura haemorrhagica* to those in which in addition there was bleeding from mucous membranes. *Schönlein's purpura* (peliosis rheumatica) was a form associated with arthritic symptoms, and *Henoch's purpura* a variety associated with abdominal symptoms. Cases with rapidly fatal hemorrhage were classed as *purpura fulminans*. *Typhoidal* and *gangrenous* forms are also described. Many of these terms are still in use. Purpuras are sometimes grouped into *symptomatic* cases occurring in conjunction with some other known pathological process and *idiopathic purpura* in which no etiology is apparent.

A more satisfactory classification takes into account the pathogenesis of the bleeding. Three general types can be distinguished. I. Thrombopenic purpuras, in which the essential difficulty is a diminution of the blood platelets. II. Purpuras due primarily to injury or weakness of the capillary wall. III. The anaphylactoid group of purpuras.

#### THROMBOPENIC PURPURA

This may be secondary to some known factor or may be idiopathic. Severe infections may cause the so-called "toxic suppression" of the bone marrow with a marked reduction of the platelets and usually anemia and leukopenia as well. A number of toxic agents are known which act similarly, the commonest of which are arsphenamine, benzol, radium and x-ray. In certain primary diseases of the blood and blood forming organs thrombopenic purpura is likely to occur, particularly in the acute leukemias, primary aplastic anemia and agranulocytosis. It is sometimes found with Banti's disease, xanthomatosis, splenomegaly of the Gaucher or Niemann-Pick type and Hodgkin's disease. Except for the presence of the associated pathological process there is nothing to distinguish these secondary thrombopenic purpuras from the idiopathic variety.

*Idiopathic thrombopenic purpura* is seen at all ages but is most common between the ages of two and ten years. The disease shows no sex predilection. Only exceptionally has more than one case in a family been observed. In the mild cases the hemorrhage is confined to the skin (*purpura simplex*), or it is accompanied by slight bleeding from the mucous membranes. There is usually some general indisposition of an indefinite character for a day or two before the purpuric spots are



noticed; most frequently a disturbance of digestion with vomiting, diarrhea, and sometimes slight fever. The hemorrhages appear as small petechiae, varying in size from a pin's head to a pea, usually first upon the lower extremities. In some cases large ecchymoses predominate. There may be only a few widely scattered spots or the body may be covered. The color is first a bright red, then purple, gradually fading in the course of a few days. New spots come as the old ones disappear, so that the amount of eruption may not diminish. They do not disappear upon pressure.

The course of these cases is generally favorable, recovery taking place in from one to four weeks. Relapses are, however, very frequent, and such attacks may come at intervals of a few weeks or months for a considerable period. One must be guarded in giving an absolutely favorable prognosis, for it occasionally happens that in a patient who for several days has had symptoms of mild purpura, there suddenly develop those of the most severe type with a rapidly fatal termination.

Severe cases are characterized by hemorrhages from the mucous membranes (*purpura haemorrhagica*) from the outset. These may even appear before the spots upon the skin. In severe attacks the petechial spots are more likely to appear suddenly, and large ecchymoses, varying in size from a pea to the palm of the hand, are frequent. There may be bleeding from the nose, gums, mouth, or pharynx, and ecchymoses may be seen upon these mucous membranes, also upon the conjunctivae. Vomiting of blood and bloody discharges from the bowels are quite frequent symptoms. The urine may contain enough blood to give it a bright red color. Less frequently there are seen hemorrhages of the retina or choroid and from the female genitals. Cutaneous ecchymoses are increased by slight injuries, such as the pressure from a bandage or from scratching. Epistaxis may be copious enough to necessitate plugging of the nares. The amount of blood vomited is not often large; its source may be the stomach, the mouth, or the pharynx. The blood in the stools is usually dark colored, but there may be some bright red blood even when no ulcers are present. There may be hemorrhages into the periarticular tissues or even into the joints themselves—usually the knee or elbow. This latter finding is rare in purpura, although common in hemophilia.

Constitutional symptoms are present in most of the severe cases. There is usually fever, from 101° to 103° F., and sufficient prostration to keep the patient in bed. If the amount of blood lost is large, there are the usual symptoms of severe anemia. The loss of blood may be sufficient to cause death, particularly in infants. Cerebral symptoms may depend upon anemia or upon intracranial hemorrhage. They are not frequent. In some of the cases beginning with severe general symptoms, and occasionally when the onset is mild, the patients after a few days pass into a typhoid condition with low delirium, great prostration, weak and irregular pulse, dry, cracked tongue, and high temperature. Such cases are almost always fatal. They are not to be confounded with ordinary typhoid fever complicated by purpura.

The course varies much in the different cases. It lasts from one to six weeks, the symptoms slowly subsiding, but often showing a strong tendency to recurrence.

Hyperacute forms (*purpura fulminans*) are rare, especially in young children. The development is usually sudden, with a chill, vomiting, marked prostration, and



high temperature. The purpuric spots come out with great rapidity, and in the course of a few hours or a day they may be very extensive. In addition to the ordinary subcutaneous hemorrhages, bloody vesicles may form upon the skin. In many cases the hemorrhages are limited to the skin, the mucous membranes and the viscera escaping altogether. Cerebral symptoms are invariably present and usually prominent; there may be delirium, dullness, stupor, and finally coma. The spleen is apt to be enlarged. This form of purpura has all the characteristics of a general infectious disease, and it is almost invariably fatal.

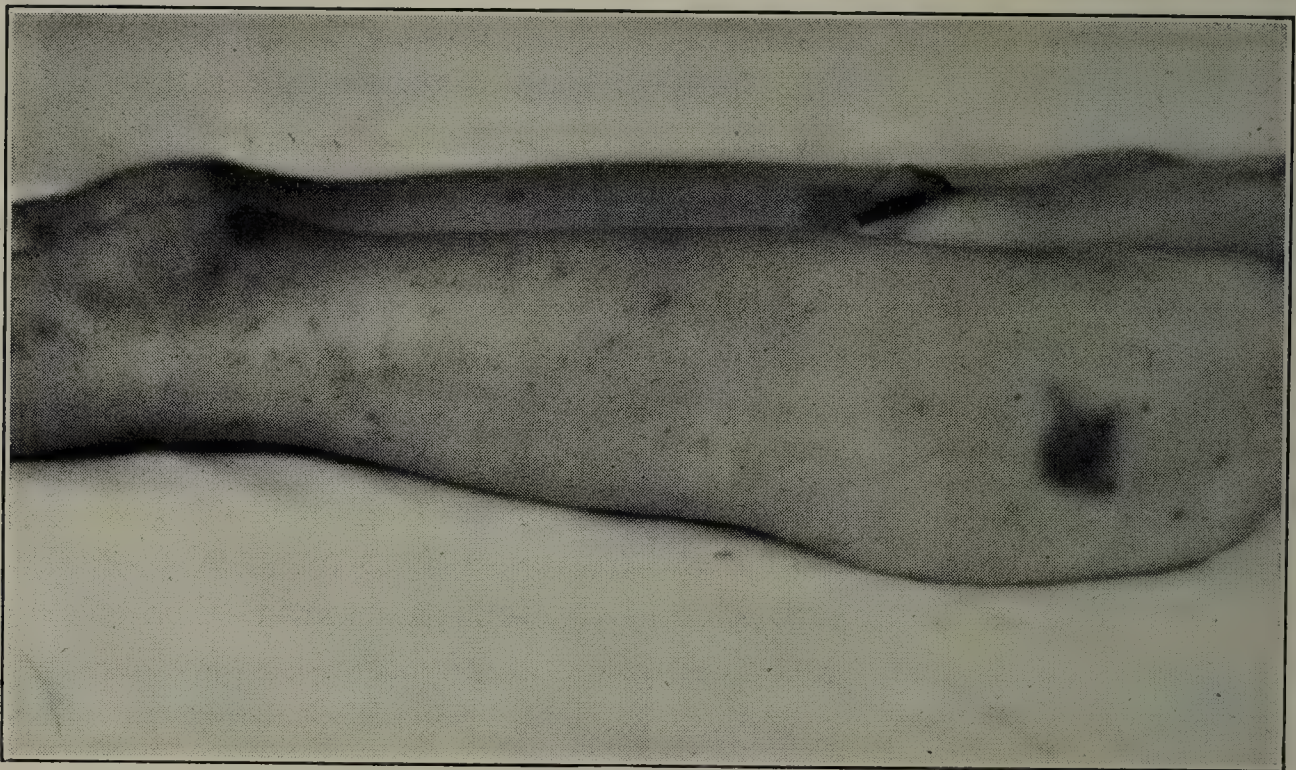


FIG. 89A.—PURPURA HAEMORRHAGICA: CHARACTERISTIC SKIN LESIONS.

Edward F. (B.H. 261351), eight years of age, had had petechiae, ecchymoses and oral bleeding for four days before admission. There was slight enlargement of the superficial lymph nodes, but the spleen was not palpable. The blood picture was that of a secondary anemia and thrombopenia (platelets, 48,000). Numerous red cells were passed in the urine. After an initial improvement lasting four days, he suddenly vomited and complained of right-sided headache, and a complete left hemiplegia set in, accompanied by fresh showers of petechiae. He died within a few hours.

Autopsy showed a right cerebral hemorrhage, with rupture into the lateral ventricle; subcutaneous, submucous, pulmonary, subpleural, subepicardial and subendocardial hemorrhages.

Gangrenous forms of purpura are rare. The skin and subcutaneous tissues are very infrequently affected, the process being most often seen in the mucous membranes. We once saw a slough which caused perforation of the soft palate. In some of the forms with mild purpuric manifestations, gangrene results from some slight injury, such as a blow, the pressure from a bandage, or in the nose, from the pressure of a tampon. Cases with extensive gangrene are nearly always fatal. Those in which the sloughing is confined to small areas of the mucous membrane of the mouth often recover.

Thrombopenic purpura gives characteristic changes in the blood. The platelets are reduced from the normal number of 250,000 or 300,000 to 100,000 or even less. Failure of the blood clot to retract on standing can be attributed directly to the low platelets. The coagulation time is normal or slightly prolonged and the coagulation factors are present in normal amounts; the bleeding time from super-



facial wounds, however, is definitely prolonged. Other changes in the blood picture are not characteristic. There is a variable amount of anemia. Often the picture is hypoplastic with a leukopenia and little evidence of red cell regeneration. In other instances, there may be many young red cells and a leukocytosis.

There is some evidence that the hemorrhage in thrombopenic purpura is not solely due to the platelet deficiency, and that increased vulnerability of the capil-

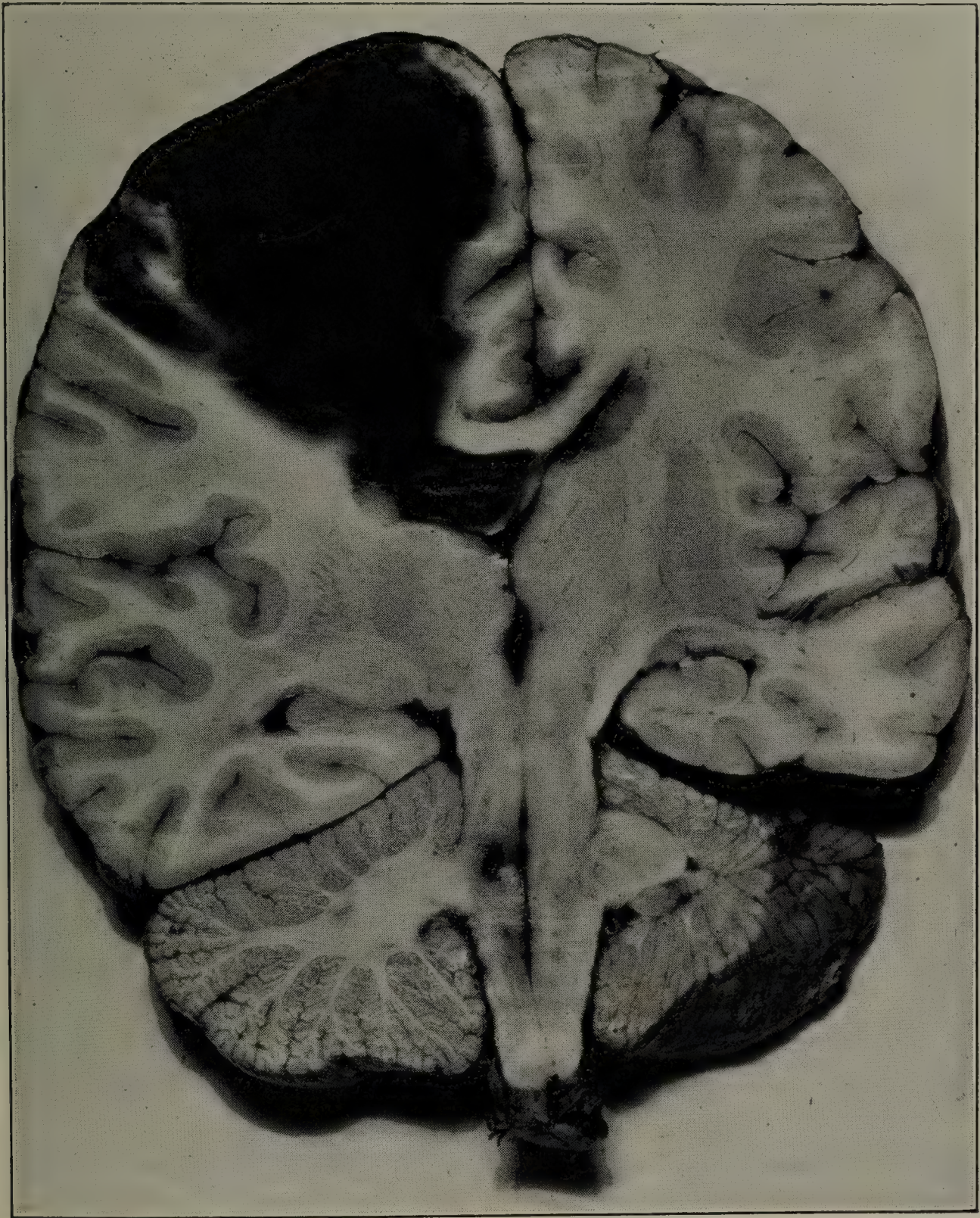


FIG. 89B.—PURPURA HAEMORRHAGICA: CEREBRAL HEMORRHAGES.

For history of this case see legend for Figure 89A.

laries may play a part. The tourniquet (Rumpel-Leede) test is usually positive, purpuric spots developing within three minutes in an extremity in which the venous return has been cut off by a constricting band. This test is by no means pathognomonic, however; it occurs in other forms of purpura, in scurvy and in some of the eruptive fevers, notably scarlet fever. Direct observations on the contractility of the capillaries after incisions have given conflicting results.



Transfusion is the only effective treatment for checking the hemorrhages, and this should be employed whenever they are extensive. Direct transfusions are preferable, since anticoagulants like citrate cause agglutination of the platelets. Nevertheless, cessation of bleeding and a rise in platelets may follow a transfusion with citrated blood.

Other methods of raising the platelet count and thereby checking bleeding are of doubtful value. Sooy and Moise reported clinical benefit and increase in the platelets following ultraviolet irradiation carried to the point of severe erythema. Our experience with this treatment has not been encouraging. Even when a rise in platelets was obtained it has been transitory, and there has been no convincing evidence of clinical improvement. Irradiated ergosterol has also been used to increase the platelets. According to Barr it does so regularly if given in sufficient dosage, but the bleeding time is not noticeably affected.

Splenectomy has been extensively used in chronic cases of idiopathic thrombopenic purpura with many favorable results. It should not be employed in acute cases, but only when there have been repeated recurrences of sufficient gravity to warrant the operative risk. The operation should be carried out between acute attacks. Not every case is benefited, but the majority are greatly improved. Following the operation the blood platelets generally rise promptly and recurrences of the purpura cease. Our experience has been, in a few cases followed for five years, that after a time the platelets begin to fall once more and that purpura may then recur. There are several instances on record, however, where some time after the operation the platelets have fallen to a level as low or even lower than that of the original purpuric attacks without any recurrence of bleeding. The size of the spleen is no criterion of the improvement to be expected from operation; marked improvement may follow the removal of a spleen that has not been palpable.

### PURPURAS DUE TO CAPILLARY DAMAGE OR WEAKNESS

Purpura with a normal number of platelets may occur in a variety of conditions:

**Infections.**—This form of purpura is very constantly seen in malignant endocarditis, in the hemorrhagic forms of the various eruptive fevers—measles, scarlet fever, variola, vaccinia, and typhus—also in epidemic meningitis and occasionally in diphtheria, pyemia, and septicemia. The occurrence of hemorrhages in these cases depends in some instances on direct bacterial invasion of the blood stream, in others on an apparently toxic damage to the capillary endothelium. It is generally a bad prognostic sign.

In many streptococcal infections, usually in cases of pharyngitis, a toxic or secondary purpura of this type occurs, with normal or even elevated platelet count, normal bleeding and coagulation time, a strongly positive tourniquet test, and sterile blood cultures. The violence of the purpuric outbreak may cause considerable temporary disfigurement. As contrasted with the types just mentioned, however, the prognosis is not necessarily bad. Recurrence of the purpura with subsequent infections is not common.

It is thus apparent that infections may bring about purpura in two different ways: by damaging the bone marrow and by damaging the blood vessels.



**Poisons.**—Certain drugs, such as phosphorus, quinine, potassium chlorate, and sometimes others, may in rare cases produce hemorrhages when long continued or in large doses. The hemorrhages of jaundice may also be considered in this group.

**Mechanical Causes.**—Mechanical causes, such as may occur in epileptic convulsions or paroxysms of pertussis, may produce purpura. In convalescence from protracted illness there are sometimes seen, when patients first stand or walk, purpuric spots on the lower extremities. They may occur after the confinement of a limb in bandages or splints. In both these conditions the cause is partly mechanical and partly due to the weakened condition of the blood vessels.

**Scurvy.**—The hemorrhages of scurvy can be attributed to a weakened condition of the capillary wall.

**Cachectic purpura** occurs in many infants exhibiting extreme malnutrition and often dehydration as well. In most cases of cachectic purpura the hemorrhagic spots are small, not very abundant, and occur either up on the abdomen or the lower extremities. This form is quite common in hospital practice, and is usually indicative of a fatal result. In cachectic purpura the hemorrhages are almost invariably limited to the skin.

**Neurological Conditions.**—Cases are occasionally seen in disease of the spinal cord, but very rarely in children.

The pathogenesis of these various forms of purpura doubtless differs. Treatment should be directed to the primary cause. Transfusions are rarely indicated.

## ANAPHYLACTOID PURPURA

This term is used to describe a group of purpuras which includes both the Schönlein and the Henoch type. The group is characterized by the following symptoms: (*a*) skin lesions—usually purpura, but at times any of the erythema group of skin diseases, urticaria or angioneurotic edema, (*b*) abdominal pain, with or without intestinal hemorrhage, (*c*) arthritic pain, due to a hemorrhagic or non-hemorrhagic arthritis, and (*d*) albuminuria or hemorrhagic nephritis.

Anaphylactoid purpura appears as a primary disease and can as a rule be distinguished without difficulty from idiopathic thrombopenic purpura. It is more often found in older children. The onset may be either with skin lesions, with arthralgia or with abdominal symptoms; there seems to be little regularity in the mode of onset. Cases in which the abdominal symptoms usher in the attack are often most confusing to diagnose. There may be acute colicky pain in any part of the abdomen, with nausea and perhaps vomiting. Constitutional symptoms—fever and leukocytosis—are present in some instances, and with such a combination there is every reason to suspect an acute surgical condition. Unnecessary laparotomies are often performed. The abdomen when opened usually shows a little free fluid in the peritoneal cavity; petechiae may or may not be found in the intestinal wall and mesentery. Microscopic observations made on the appendix removed in such instances have shown a delicate layer of fibrin on the peritoneal surface, thickening of the serosa with edema, minute hemorrhages, mononuclear cells and a few leukocytes. In some instances larger hemorrhages are found infiltrating the intestinal wall for several inches, and a number of cases are reported in which this condition has led to intussusception. We have not encountered this particular complication but we



have seen an instance in which ovarian hemorrhage resulted in a serious abdominal complication. The case history (taken from Trimble's report) follows:

A girl, aged six years, began having intermittent cramp-like abdominal pain ten days previous to admission; for three days she had vague rheumatic pains in her legs and arms, and twenty-four hours before admission a few red spots appeared on the buttocks and legs.

On admission to the hospital she had several brownish red, maculopapular, hemorrhagic lesions over the ears, face, hard palate, elbows, forearms, buttocks, legs, and soles of the feet; the temperature was 98.2° F.; the urine was normal.

She remained in the hospital for five months, suffering intermittent severe attacks of abdominal pain, followed almost always by a hemorrhagic skin eruption, and many times by melena. On one occasion the joints of the fingers of the right hand and of both knees were very swollen and tender; on other occasions, a soft mass the size of a hen's egg was felt in the lower right abdominal quadrant and a small tender mass over the lower ribs in the anterior axillary line on the right side, but both the masses disappeared after several days. At another time the right eyelid and practically the whole scalp became edematous and painful. She improved a great deal, although the urine never became entirely free from blood and casts.

She was well for two years, except for occasional attacks of mild abdominal pain followed by a purpuric skin eruption, when suddenly she was seized with great pain in the abdomen and with vomiting. She had a temperature of 99° F.; there was marked abdominal tenderness, especially on the lower right side; in the midline about 6 centimeters above the pubis was a hard, pear-shaped mass that was tender and lay close to the abdominal wall; the urine was normal. No rash appeared.

At operation it was found that the right ovary, which contained a large hemorrhage, had become semigangrenous owing to a twist of its pedicle. The patient made an uneventful recovery.

Not all these attacks of abdominal purpura are accompanied by blood in the stools, but this is a frequent finding; the blood may be fresh or changed. Hematemesis may occur.

Skin lesions may follow or precede or appear simultaneously with other manifestations. Purpura is by far the most common lesion; large blotches are infrequent, more often there are petechiae which may develop symmetrically. Bleeding from the mucous membranes is rare. Instead of purpura and sometimes in association with it there may occur any of the exudative erythemas, urticaria or angioneurotic edema. This last is usually confined to the face or eyelids.

In the joints pain is out of proportion to the objective symptoms. Sometimes there is swelling as well. Effusions into the joint are usually serous, rarely sanguineous. The knee and ankle are most often affected.

Albuminuria is very common in these cases. There may be casts as well, and, in some instances, all the evidences of acute hemorrhagic nephritis.

The blood as a rule shows no reduction in the platelets or change in the character of clot. Occasionally a moderate reduction of the platelets is met with. Eosinophilia is sometimes a conspicuous feature. The capillaries do not appear to be abnormal and the tourniquet test usually fails. The spleen may be enlarged in certain instances of the disease.

Anaphylactoid purpura follows no typical course. New manifestations or recurrences of the original feature may continue irregularly for days or weeks. Recurrences may occur at any time thereafter, even after years have passed. Permanent



damage to the joints is rare, but has been described. Chronic nephritis occasionally follows the acute.

The nature of this type of purpura is by no means clear. Hypersensitiveness to proteins of one type or another has been demonstrated in some instances, notably by Alexander and Eyermann, but this cannot be regularly established. In other instances focal infection appears to play an important part. There can be no doubt that a grouping such as has been described includes many instances of rheumatic fever; in the absence of typical nodules, chorea or some cardiac complication, such an etiology can only be suspected.

The greatest difficulties in diagnosis are caused by the abdominal manifestations. Anaphylactoid purpura should be kept in mind as a cause of acute abdominal pain, and in the presence of joint symptoms or skin lesions one may well hesitate before opening the abdomen. The possibility of serious abdominal complications must, however, be remembered.

In treating these cases, a search for offending antigens is always indicated. In certain cases where there is a chronic focus of infection, some relief may be obtained by desensitizing injections of an autogenous vaccine. Apart from this the treatment is largely symptomatic. Transfusions and subsequent dosage with iron may be indicated if there are large hemorrhages, but this is seldom the case. Since rheumatic fever is often impossible to exclude, it is well to treat these cases most conservatively with rest in bed and with salicylates, and, above all, to watch for rheumatic complications.

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## SECTION X

### *DISEASES OF THE SPLEEN AND LYMPH NODES*

#### CHAPTER LXV

#### DISEASES OF THE SPLEEN

##### POSITION AND METHODS OF EXAMINATION

The thin abdominal wall of young children renders palpation of the spleen easier than in adults; this is a much more satisfactory method of examination than is percussion. Under ordinary conditions the spleen can easily be felt when it is sufficiently enlarged to be of any diagnostic importance.

When moderately enlarged, the lower border of the spleen is an inch or so below the free border of the ribs; when greatly enlarged, it forms a tumor which may nearly fill the left half of the abdomen. A tumor in the left hypochondriac region is recognized to be the spleen by the sharpness of its mesial border, at about the middle of which a notch may be felt, and by the fact that it rides along the anterior abdominal wall, superficial to the descending colon, and can be readily displaced mesially, laterally or upward. Only when greatly enlarged does it extend sufficiently far posteriorly to be felt in the left costovertebral angle. A renal or adrenal tumor is occasionally mistaken for an enlarged spleen. In such instances the relation of the mass to the colon is helpful in diagnosis—the colon being anterior to masses of renal origin.

##### ENLARGEMENT OF THE SPLEEN

The tip of the spleen is palpable in many normal subjects up to three or four years of age. It can often be distinctly felt in infants with eczema. Acute splenic tumor is likely to be met with in any acute infectious disease—the enlargement, except in typhoid fever and malaria, is rarely marked. In many chronic infections enlargement of the spleen is found, notably in tuberculosis, syphilis and malaria. Chronic passive congestion is, of course, an important cause of splenomegaly. It is usually caused by obstruction to the systemic circulation as in cardiac insufficiency; rarely by local obstructions of the splenic or portal vein, or hepatic cirrhosis.

Enlargement of the spleen occurs in various blood diseases; in secondary anemia; in primary anemias such as erythroblastic anemia, sickle cell anemia and hemolytic jaundice; in leukemia and in some instances of purpura. In Gaucher's disease and lipoid histiocytosis (Niemann-Pick disease) splenomegaly is usually the most conspicuous symptom. Amyloid disease may cause enormous enlargement of the



spleen. Neoplasms are rare in childhood. Tropical splenomegaly (leishmaniasis) has been reported in the United States.

It is often stated that rickets causes enlargement of the spleen. In our experience this has not been the case unless marked anemia has been present as well. The spleen is, however, more readily palpable in rickets, owing to the weak abdominal musculature and the flaring of the costal margins.

Most of the conditions associated with enlargement of the spleen have been discussed elsewhere.

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## CHAPTER LXVI

### DISEASES OF THE LYMPH NODES

It is characteristic of infancy and childhood that the lymphoid tissues respond with an unusual degree of swelling and hyperplasia. Moreover, the hyperplasia may persist for a long time after the primary exciting cause has subsided. This tendency is met with in all parts of the body. In the upper respiratory tract it manifests itself by the familiar hypertrophy of the tonsils and adenoids, but any of the external or internal lymph nodes exhibit this same tendency.

As age advances retrogressive changes take place in the various lymphoid structures, and the response of regional nodes to acute infections tends to diminish. Those connected with the digestive tract begin to subside after the second year, and by the fifth or sixth year the enlargement has almost disappeared. The tonsils, adenoids and cervical nodes tend to diminish around the seventh or eighth year and may undergo marked atrophy at the time of puberty.

The cause of the marked lymphoid response in early life has been attributed to the fact that the child lacks acquired resistance toward many infectious agents. It is characteristic not only of tuberculosis but of many pyogenic infections that a first infection meets with little resistance at the portal of entry; it travels rapidly to the regional lymph nodes where it may cause considerable reaction. A subsequent infection with the same organism finds the body with a certain degree of acquired resistance; the infectious agent finds difficulty in getting beyond the portal of entry and may never reach the regional lymph nodes.

Heredity seems to play an important part in resistance to infections in general, and this is borne out by the behavior of the lymphoid tissues. Enlarged tonsils and adenoids and marked cervical adenitis are often found in every member of a large family; frequently the parents, during childhood, have been similarly affected.

**Simple Acute Adenitis.**—A certain amount of secondary involvement of the lymph nodes accompanies practically all inflammatory processes. In young patients it not infrequently outlasts the original infection or greatly overshadows it in clinical importance, and in infants acute adenitis often comes close to being a disease *sui generis*. Of the cases from our records, not including any associated with diphtheria, measles, or scarlet fever, more than three-fourths occurred in the first two years, and half of them in the first year of life.

The condition most commonly follows infections of the upper respiratory tract, with involvement of the cervical nodes; it may also be seen in the glands of the axillae, the groin, or even internal nodes like the mesenteric and retroperitoneal group. Enlargement of lymph nodes may be the chief complaint in pharyngitis, ulcerative stomatitis, caries of the teeth, pediculosis, rubella, vaginitis, balanitis, and in some skin infections and superficial wounds. Unless abscesses form, one does not learn with certainty what organism is responsible, or whether viable organisms



are present at all. In the majority of cases of acute suppurative adenitis, beta-hemolytic streptococci are found; but pneumococci, staphylococci, and other organisms occur, depending on the location and specific nature of the primary process. Cervical adenitis accompanying scarlet fever not infrequently terminates in suppuration.

Some swelling accompanies the primary infection, but it may increase even after this has completely healed, sometimes reaching after two or three weeks the size of a walnut or a hen's egg. Size alone does not indicate whether the node will eventually break down. There is great variation in individual cases in the time occupied by the increase and subsequent diminution in size, but this is hardly ever less than a week; and in many the gland does not return to normal for weeks or even months, passing from the acute to the chronic stage. In primary affections of the throat the ensuing adenitis is often bilateral, particularly in young patients, and more than one gland may be involved on each side. Cervical adenitis often causes a stiffness of the neck as a protective reaction that may be as definite as in meningitis. With great swelling, the soft tissues of the lateral pharyngeal wall may be displaced medially, simulating peritonsillar or retropharyngeal abscess, and the voice may be affected. In the most acute examples of adenitis there is marked inflammation of the periglandular tissues, with pain, tenderness, and local heat. In many the node remains firm throughout; in others it becomes so soft at the height of the swelling as to suggest fluctuation, and in still others it actually breaks down. If suppuration occurs, this is generally evident in the latter part of the second week, but sometimes it may be as late as the third or even the fourth week. In general the cases with the most rapid enlargement are accompanied by the most severe general reaction, though there are many exceptions.

Many cases run their course with slight fever and few general symptoms; but in young infants the constitutional reaction is often severe, particularly in the first week, and the physician may be in doubt whether the local process is sufficient to explain it. A sustained high temperature is not uncommon at the onset of severe cases. Later it becomes remitting in type, with wide fluctuations during the course of twenty-four hours. Daily swings from 98° F. in the morning to 103° or 104° F. by late afternoon may be repeated for as long as four weeks, even in cases where the infection does not go on to frank abscess formation. Many of these patients show relatively little concomitant anorexia and malaise. Suppuration, when it occurs, develops earlier in infants than in older children.

The diagnosis is not difficult if physical examination has been complete. The main trouble comes from failure to appreciate the disturbance which acute adenitis may cause in young patients. We have even seen convulsions accompanying this condition. Severe swelling has often been mistaken for mumps. In some young patients giving a mononuclear type of leukocytic response the condition may resemble infectious mononucleosis (glandular fever), and it must be admitted that the line cannot be sharply drawn. Adenitis invariably accompanies retropharyngeal abscess, and one must be on guard not to overlook the latter just because one explanation of most of the symptoms has been found. The acute form of cervical adenitis has little in common with the slow progression of tuberculous involvement, but we have seen the former light up the latter.



The general symptoms should receive appropriate treatment. It is generally agreed that cold applications over the enlarged nodes may have some effect in preventing abscess formation. When fluctuation has once appeared, hot local applications should be used to accelerate the localization of the abscess and to bring it to the surface. If surgical intervention is deferred until pointing has taken place, with discoloration of the overlying skin, the abscess generally heals promptly and leaves but a small scar. Spreading of the infection to adjacent nodes or the development of a diffuse cellulitis are usually the result of local manipulations, particularly of premature surgical intervention. The disastrous cosmetic results of injudicious operative attempts are often a cause of life-long regret. Treatment of the primary condition giving rise to adenitis should not be neglected. We regard the occurrence of a severe attack of cervical adenitis as an indication for tonsillectomy, which may be undertaken when the attack has subsided.

*Adenitis of the internal lymph nodes* is not readily recognized. We have seen several instances in which an attack of acute abdominal pain associated with fever and leukocytosis revealed at operation only one or perhaps more greatly hypertrophied mesenteric lymph nodes. Brennemann in particular has called attention to this condition. Involvement of the retroperitoneal nodes usually gives rise to psoas spasm.

**Hodgkin's Disease (Pseudoleukemia, Lymphogranulomatosis).**—Hodgkin's disease is characterized by a chronic painless and progressive enlargement of the lymph nodes. It is a rare condition, only 10 cases have been seen among 70,000 admissions to the Harriet Lane Home, the youngest being three years old. In infancy it is almost unknown, but it is found with increasing frequency throughout childhood. It is more common in males.

*Etiology.*—The essential cause of Hodgkin's disease is unknown. Although it has been regarded by some as neoplasm, the general view is that it is an infectious granuloma. Numerous organisms have been described in connection with it, especially diphtheroids and modified forms of the tubercle bacillus; most recently, the avian tubercle bacillus. It is doubtful if the disease results from infection with any one of them. The disease has not been transmitted to animals.

*Pathology.*—The chief lesion is in the lymph nodes, which become greatly enlarged; new nodes often appear during the course of the disease. Those first affected are usually in the neck, but any of the external or internal groups of lymph nodes may be affected and in severe cases the disease may involve almost every chain of nodes in the body. Of the internal nodes those of the mediastinum and retroperitoneal region are usually most affected. Large masses are formed by the growth and multiplication of the lymph nodes, but even in the largest masses the individual nodes are usually discrete and are held together only by loose connective tissue. The spleen is often, the liver less frequently, involved and somewhat enlarged by the formation of masses of new tissue, which may also infiltrate almost any structure of the body. In the early stage the lymph nodes are elastic, homogeneous and have a rather translucent appearance. On section they often have a pinkish or creamy color.

The microscopic appearances are very definite. Three stages can be distinguished. Early in the disease there is a simple hyperplasia of the lymph nodes,



which presents nothing characteristic. There follows a gradual disappearance of the normal architecture, this being replaced by an irregular reticular network in which various kinds of cells are found: lymphocytes, mononuclear wandering cells, eosinophils, epithelioid cells and the very characteristic polynuclear giant cells first described by Dorothy Reed. These are large irregular cells with pale clear cytoplasm and several nuclei which are heaped together; the nucleoli are especially prominent. If these cells are absent the diagnosis of Hodgkin's disease cannot be made. In the third or final stage the glands become fibrosed and may be replaced by hyalin. The masses in the spleen and elsewhere have the same microscopic structure as the diseased nodes.

*Symptoms.*—The first evidence of the disease is usually swelling of one or more cervical nodes. Thereafter, there is a progressive involvement of other nodes, though the rapidity with which this occurs may vary greatly. The glandular masses can be felt to be made up of discrete nodes. These are elastic, sometimes distinctly soft; again, firm. They are more or less movable and not adherent to the deeper structures or to the skin over them. At any time symptoms may appear as the result of the mechanical pressure of the nodes. This may be on the vessels of the neck or extremities, producing edema; upon the esophagus, producing dysphagia; or upon the trachea or bronchi, producing dyspnea. Intra-abdominal pressure may cause jaundice or ascites. In most cases enlargement of the spleen can be made out; in some instances it is extreme. Although the typical onset is with enlargement of the cervical lymph nodes, this is not invariably the case. Symptoms of mediastinal or abdominal pressure may be the first to attract attention. In other instances the onset may be with fever, lassitude or loss of weight. Occasionally the disease starts with a persistent generalized pruritus.

Constitutional symptoms are regularly present when the disease is well developed. Usually there is an elevation of temperature of only a degree or two which is persistent. Attacks of high fever lasting a week or two followed by complete remissions may recur at intervals with great regularity (fever of Pel-Ebstein type). The blood shows the characteristics of a secondary anemia, which increases in severity. The leukocytes may be slightly diminished or increased, but in the late stages there is usually a polymorphonuclear leukocytosis (20,000 to 30,000 or more). There are two fairly constant features, an increase in the blood platelets and an increase in the monocytes. Eosinophils, while usually somewhat diminished, may be present in great numbers.

The duration of the disease is usually less than three years; it may run a very rapid course, terminating in a few weeks. Periods of spontaneous arrest may occur, and remissions may follow treatment, but the effect is usually temporary. Death results from asthenia or from pressure, usually upon the respiratory tract, producing most distressing dyspnea. The prognosis is decidedly unfavorable.

*Diagnosis.*—The diagnosis of Hodgkin's disease may be difficult at the beginning, when only a few cervical nodes are enlarged. It may be confounded with tuberculosis of the lymph nodes, with lymphosarcoma and with leukemia. From tuberculosis it is to be differentiated by the wide distribution of the progressively enlarging nodes; by their failure to coalesce, to exhibit inflammatory reaction or to suppurate; by the frequent absence of the tuberculin reaction and by the more



malignant course and pressure symptoms. Calcification of the glands may occur in tuberculosis but not in Hodgkin's disease. Lymphosarcoma is more rapid in its course, and rarely causes fever; the nodes do not remain so discrete as in Hodgkin's disease and the spleen is seldom involved. Lymphosarcomatous masses are more often localized. In certain instances the clinical differentiation is impossible. Leukemia is distinguished by less lymphatic enlargement, by greater rapidity of progress, especially in the lymphatic form, and especially by the character of the blood findings. In doubtful cases the excision and examination of a node will almost always give reliable information as to the presence of Hodgkin's disease.

The x-ray picture of mediastinal Hodgkin's disease is characterized by a surprisingly uniform widening of the mediastinal shadow (Fig. 90).

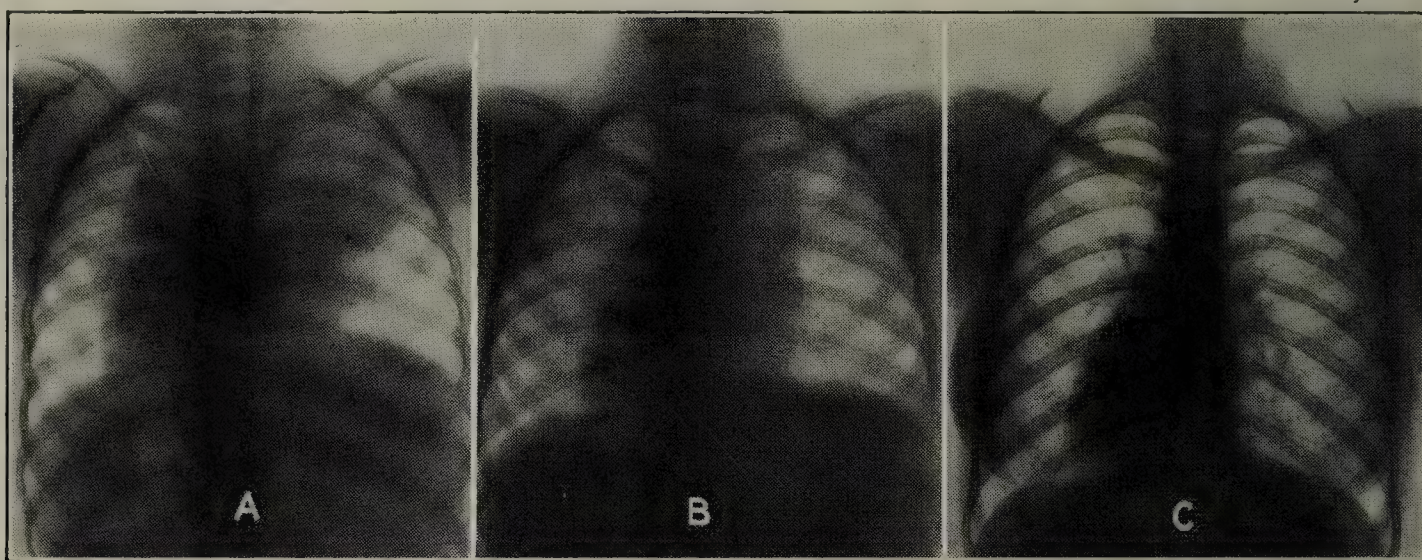


FIG. 90.—ROENTGENOGRAM OF MEDIASTINAL HODGKIN'S DISEASE.

A, before treatment. B, one month after radium treatment. C, six years after onset.

*Treatment.*—Some improvement is said to follow the administration of arsenic in the form of Fowler's solution or sodium cacodylate. This has largely been given up since the advent of radium and x-ray therapy.

Radiotherapy often produces very striking results. Large glandular masses may melt away with surprising rapidity followed by complete relief from obstructive symptoms. The effect is rarely permanent. In most cases, after a period of weeks the masses begin to enlarge once more, and there develops a tolerance to therapy. In some instances further therapy is contraindicated by a marked degree of leukopenia, anemia and thrombopenia. C. F. Burnam, who has had a wide experience in treating these cases, tells us that 10 to 15 per cent of his cases have shown no tendency to recur even after an interval of ten years, and in some instances more than fifteen years have elapsed. We have seen one such favorable result, the history of which is appended.

A white girl (H.L.H. 48075) had been normal up to the age of eight years when she developed mumps. After the main swelling subsided it was noticed that the cervical lymph nodes remained enlarged. Several months later it was noticed that the axillary nodes were considerably enlarged. Irregular attacks of fever and anorexia then developed, accompanied by increase in the size of the glands; these would diminish somewhat between febrile attacks. Ten months after the onset of glandular swelling the patient was brought to the hospital because she was losing weight and had developed a chronic cough. Physical examination showed moderate pallor. There were numerous discrete



glandular masses in the cervical chain, below the left clavicle and in both axillae, many of them as large as a walnut and the largest as big as a small lemon. Asymmetry of the chest was caused by the mass of enlarged nodes below the left clavicle; dilated veins were evident in this region. The spleen was palpable. The chest showed tubular breathing over the mediastinum, and an x-ray gave the picture shown in the accompanying illustration. The temperature was  $101^{\circ}$  F. The blood count showed R.B.C. 3,800,000, hemoglobin 60 per cent. There were 30,000 leukocytes, the differential count being P.M.N. 77 per cent; P.M.E. 1 per cent; lymphocytes 15 per cent; monocytes 7 per cent. The platelets were 275,000. The patient's fever varied between  $99^{\circ}$  and  $105.6^{\circ}$  F. The tuberculin test was repeatedly negative, although the dose was increased to 5.0 milligrams intradermally. A cervical lymph node was excised and showed the typical picture of Hodgkin's disease.

The patient was given three radium treatments at five-day intervals. This caused disappearance of the fever, a drop in leukocytes to 7200 and subjective improvement. During the ensuing six months she was given occasional treatments with radium. Treatment was then discontinued because of the great shrinkage in the size of the external glands and mediastinal shadow. No more febrile attacks occurred. She has been followed at intervals since then, and has had no recurrence. At the time the last x-ray (Fig. 90, c) was taken, the patient, some six years after the onset of the disease, was apparently in the best of health. A few small cervical and axillary nodes were palpable, but no more than in the average normal individual.

According to Burnam the cases which are likely to respond favorably are those characterized by very marked enlargement of the external nodes; early therapy improves the prognosis. In the type with little lymphoid enlargement but with progressive weakness and anemia radiotherapy is disappointing.

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## SECTION XI

### DISEASES OF THE DUCTLESS GLANDS

#### CHAPTER LXVII

#### DISEASES OF THE THYMUS

At birth the thymus is a relatively large organ. It casts a shadow which is easily visible in the x-ray. During infancy there is a *relative* (though not an absolute) decrease in the size of the gland. This continues throughout the period of body growth, as is shown in the accompanying table. The thymus shadow can rarely be detected after the second or third month in normal individuals.

TABLE XL

VARIATIONS IN WEIGHT OF THE THYMUS AT DIFFERENT AGES, COMPILED FROM 337 INDIVIDUALS WHO HAVE MET ACCIDENTAL DEATHS (AFTER HAMMAR)

Age	Weight in Grams			Per Cent of Body Weight *
	Maximum	Minimum	Average	
Newly born .....	26	7	15	0.45
1- 5 years .....	48	8	26	0.20
6-10 years .....	48	13	29	0.12
11-15 years .....	43	19	29	0.07
16-20 years .....	50	16	26	0.04
21-25 years .....	51	10	21	0.03
26-30 years .....	52	8	20	0.03
31-35 years .....	37	9	20	0.03
36-45 years .....	36	6	19	0.03
46-55 years .....	45	6	17	0.025
56-65 years .....	27	2	14	0.02
66-90 years .....	31	3	14	0.02

\* Calculated from Hammar's average figures and normal weight tables.

**Simple Enlargement of the Thymus.**—This is not very uncommon in the early weeks of life; it is rare thereafter, and after the age of two it is practically unknown. The condition appears to be more frequent in certain localities. It may be accompanied by enlargement of the superficial lymph nodes and the spleen. Extreme enlargement may be found accidentally by an x-ray examination when no symptoms are present. In certain instances rather definite signs are associated with moderate enlargement. There is a somewhat brassy cough, a noisy rather than difficult respiration and perhaps attacks in which respiration is actually difficult with periods of cyanosis. The cyanosis may not be accompanied by dyspnea.



With the bronchoscope, Chevalier Jackson has observed thymic pressure on the trachea in such patients. In the most extreme cases, paroxysmal dyspnea and cyanosis may be intense and convulsions may occur. Death rarely takes place in these attacks, though it may appear imminent.

The symptoms are apt to persist for some weeks or months and then gradually disappear even without treatment. In a few instances they are progressive and there

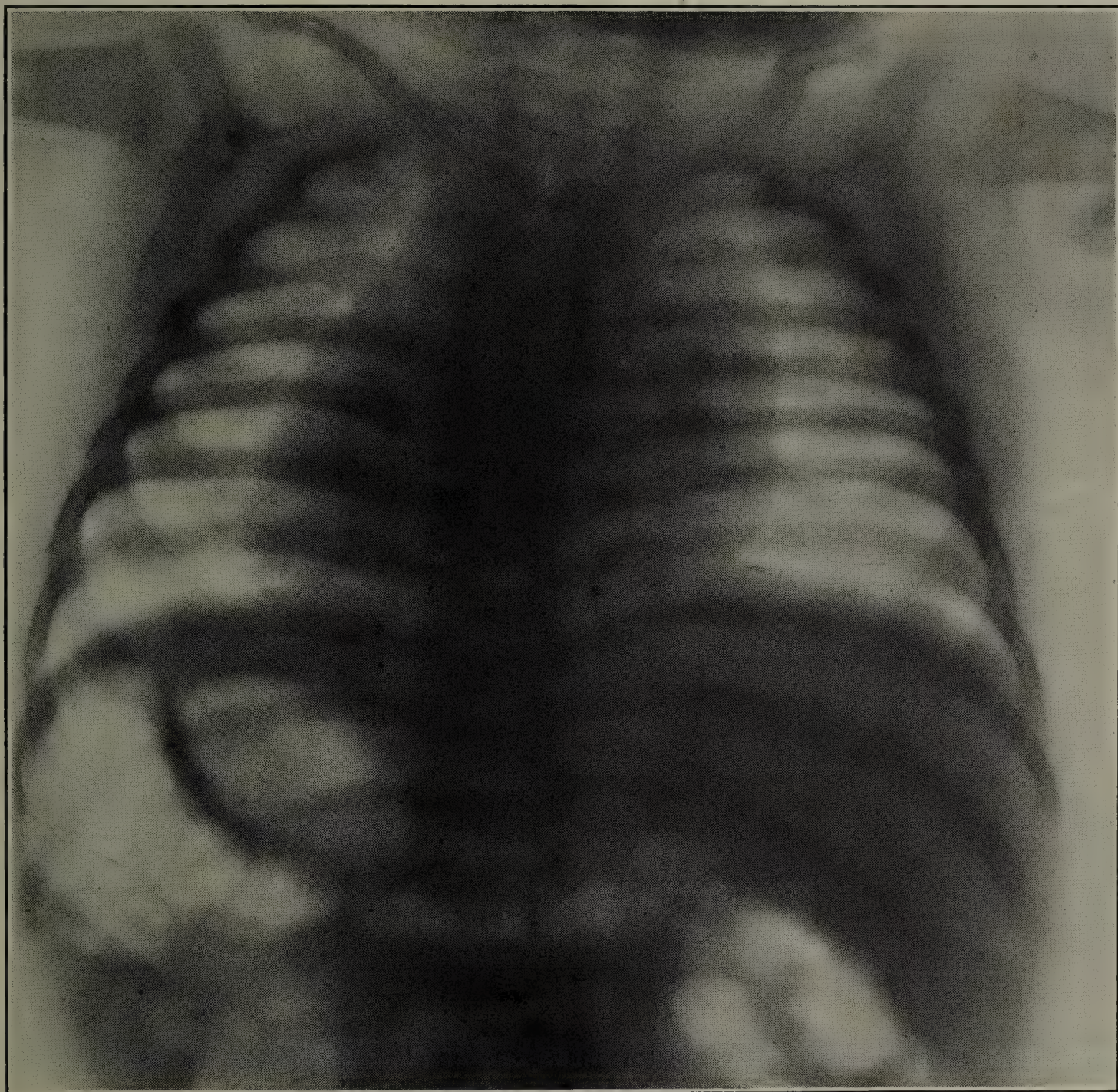


FIG. 91.—SIMPLE ENLARGEMENT OF THE THYMUS.

The patient, an infant two months of age, had had frequent attacks of cyanosis.

are reports which would seem to indicate that death has occurred from increasing obstruction to respiration. This is undoubtedly a very unusual outcome.

Evidence of enlargement of the thymus may be obtained by percussion or by the x-ray. Dulness is frequently determined in the second interspace to right and left of the sternum. It is continuous with the cardiac dulness. Considerable experience is required to detect this dulness, and the results must be interpreted with care, for frequent errors are made. The x-ray shadow cast by an enlarged thymus is usually sharply outlined and overlies the supracardiac shadow or the upper part of the heart. Pancoast has called attention to the possibility of demonstrating tracheal compression at the level of the superior thoracic strait in x-rays taken in the



lateral position. In anteroposterior views the shadow of the thymus may be simulated by enlarged mediastinal nodes, distended vessels, and occasionally other structures.

The diagnosis of thymic enlargement is often wrongly made on clinical evidence. In the majority of patients who have been brought to us with this diagnosis already made on the basis of stridor, cyanotic spells, or convulsions, some other condition has been responsible—most commonly deformity or disease of the larynx, less often atelectasis, congenital malformation of the heart, or even tetany.

In cases where enlargement has been demonstrated, treatment by means of the x-ray is almost always successful. Four or five exposures are made directly over the thymus region every week or two. If partial or complete involution has occurred no further radiation is necessary unless the gland is increasing in size. This not infrequently happens but repetition of the treatment again reduces the size.

**Status Lymphaticus.**—In this syndrome, first described by Paltauf in 1889, there is sudden death from apparently trivial causes; at postmortem enlargement of the thymus and of all the lymphoid tissues of the body is found. Death may occur after very slight accidents, a needle prick, the administration of an anesthetic, intense excitement or such a mild infection as a common cold. Death usually occurs with great rapidity, with sudden circulatory failure; in some instances it may be preceded by symptoms of asphyxia. There may be convulsions. The condition is most often seen in early life.

Although such instances of sudden death are met with from time to time, there is grave doubt that they are in any way related to the lymphatic system or that such an entity as status lymphaticus really exists. For the explanation of the apparent hypertrophy of the lymphoid tissue found at autopsy we are largely indebted to the painstaking work of Hammar. It is now perfectly clear that the lymphatic enlargement found at autopsy in these cases of sudden death represents the normal condition in childhood. Infants and children who meet accidental deaths show lymphoid structures and thymus glands quite as large as those dying of "status lymphaticus." The error lay in accepting as normal values for the size of the thymus and lymphoid tissue data based on routine autopsies. In nearly all diseases, and particularly in those accompanied by wasting, there is a marked atrophy of all the lymphoid tissues; the thymus at autopsy may be found to be only one-third of the average normal weight. Only observations based on cases of accidental death can be used as normal standards. The accompanying figures taken from Boyd illustrate the influence of the general nutrition at the time of death on the weight of the thymus:

TABLE XLI  
INFLUENCE OF NUTRITION ON WEIGHT OF THYMUS (FROM BOYD)

Nutrition	Birth	2 Weeks	6 Months	13 Years
Good .....	13 grams		20 grams	35 grams
Poor .....		8 grams	6 grams	13 grams

In starvation experiments in animals it has been shown that the thymus loses weight more rapidly than any other organ.



The explanation of sudden death from apparently trivial causes is as yet completely obscure. An interesting suggestion has recently been made by MacLean and Sullivan, who found a low level of spinal fluid sugar at the time of death in such instances, indicating that the carbohydrate metabolism might lie at the root of the difficulty. The claim that so-called thymic death may be prevented by routine pre-operative x-ray investigation, when an anesthetic is to be given, is not justified by the available evidence.

A great deal of mystery has surrounded the thymus and its supposed atrophy after puberty, which has suggested an intimate relation between it and the sex glands. A glance at Table XL, however, in which the weight of the thymus is compared to the weight of the body as a whole, indicates that there is no sudden decrease in the thymus at the time of puberty, but rather a steady decrease in the relative weight of the thymus from birth on. This runs roughly parallel to the diminishing proportion of lymphocytes in the circulating blood as age increases.

The thymus has been regarded as an organ of internal secretion, and there are reports of various active principles that have been extracted from it, most recently by Nitschke. It remains to be demonstrated, however, that such physiological effects as have been described are in any way specific for this organ. It would be idle to deny that the thymus is an organ of internal secretion, but at the present time its function—if it has one other than that of producing lymphocytes—is completely obscure. Park and McClure were unable to demonstrate any significant change in experimental animals from which the thymus gland was removed.

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## CHAPTER LXVIII

### DISEASES OF THE THYROID GLAND

#### CRETINISM

Since the early descriptions of this disease by Fagge, in 1871 and 1874, numerous cases have been published all over the world, showing that sporadic cretinism is not confined to any country. The condition is a relatively rare one, but in a large dispensary and hospital service one or more examples of it are seen every year. It is also called athyreosis and myxedematous idiocy.

**Etiology.**—The condition depends on insufficiency of the internal secretion of the thyroid gland. In most of the autopsies in cases of sporadic cretinism that have been reported there has been an entire absence of thyroid tissue, due to a congenital lack of development. In one or two instances cysts containing cells resembling thyroid have been found in the region of the lateral rudiments of the gland, or at the root of the tongue in the region of the median rudiment.

There are no recorded observations upon cases of sporadic cretinism that would indicate that an already developed thyroid gland had been affected by injury or disease. As a rule only one case occurs in a family, the other members of which present nothing abnormal in mental or physical development.

There are associated no constant changes in the other ductless glands. In the few cases in which the parathyroids have been searched for an autopsy they have been found. Alterations in the pituitary gland have been quite frequently reported. It has been found hypertrophic and occasionally cystic, but this is not constant.

**Symptoms.**—The symptoms of cretinism in most cases make their appearance during the second half of the first year, but are sometimes so slight as not to be noticed until children are two or three years old. Very rarely the condition is recognized as early as the third or fourth month. The delay in development of symptoms is to be ascribed to the protection afforded the infant by the thyroid secretion of the mother during intra-uterine life. This view is substantiated by the rare but undoubted instances where women with goiter have given birth to infants with cretinism which was clinically recognizable at birth. Failure to grow and to develop mentally are usually the first things to attract attention. The peculiarity of the facial expression is soon noticed. The general appearance of the cretin is striking, and so characteristic that when once seen the disease can hardly fail to be recognized (Figs. 92, 94). The body is greatly dwarfed, and children of fifteen years are often only two and a half or three feet in height. With cretins of eight or ten years the measurement from the navel to the sole is often less than from the navel to the crown, as it is in early infancy. There is almost complete lack of growth at the epiphyseal junctions and great delay in the development of the centers of ossification. Roentgen-ray studies show that the nuclei of the tarsal and



carpal bones appear late; they may be absent until the tenth year; the epiphyses of the long bones may not be united until the twentieth or thirtieth year. The subcutaneous tissue seems very thick and boggy, but does not pit upon pressure like ordinary edema. The facies is characteristic. The head seems large for the body; the fontanel is often open until the eighth or tenth year, and it may not be closed even in adults, but the cranial bones are often thick; the forehead is low and the base of the nose is broad, so that the eyes are wide apart; the lips are thick, the mouth half open, the tongue usually protrudes slightly; the cheeks are baggy, the eyelids thick, and in many cases the hair is coarse, dry and straight. The teeth appear very late and are apt to decay early. The second dentition may not begin until adult life.

Fatty tumors are quite constant in older children, although they are often wanting in infantile cases. They are seen in the supraclavicular region, just behind the sternomastoid muscle, sometimes in the axilla, or between the scapulae, and sometimes in other parts of the body. In distribution they are apt to be symmetrical and are often half the size of a hen's egg. The neck is short and thick. No thyroid gland can be made out by palpation, but a small cyst may sometimes be felt at the root of the tongue. The chest is not deformed. The abdomen is large and pendulous. An umbilical hernia is almost always present. Almost invariably cretins suffer from constipation. The skin is dry, perspiration scanty, and eczema is common. Pallor is often conspicuous. The voice is hoarse and rough.

Frequently patients may not walk until they are five or six years old, and then they waddle in a clumsy way. All the movements of the body are slow and lethargic, and everything indicates mental and physical torpor. The rectal temperature is usually subnormal. We had once an opportunity to observe an attack of acute pneumonia in a cretin two years old. The symptoms and physical signs were typical, but during the greater part of the disease the rectal temperature fluctuated between  $95^{\circ}$  and  $98.5^{\circ}$  F. Only once was a temperature above  $99^{\circ}$  F. recorded. On account of their low temperature and torpid condition these patients are very sensitive to cold. They live upon a low plane of metabolism and the energy exchange is small. Talbot has determined the basal metabolism of a number of cretins; it is greatly lowered. The mental condition is always greatly impaired; some are even imbecile. Cretins are dull, placid, and good-natured, rarely troublesome or excitable; and when fifteen or eighteen years old they appear like children of three or four years. Speech may be impossible; the ability to say a few words is acquired late, and in some cases not at all. There is great delay in the development of the sexual organs.

**Diagnosis.**—The diagnosis of the fully developed condition is very easy. The facial expression, the protruding tongue, the pendulous abdomen with umbilical

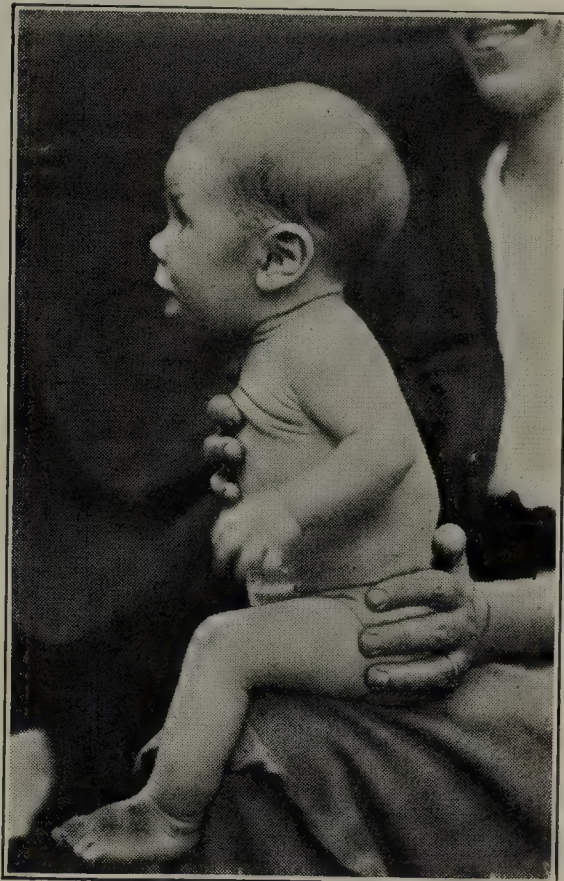


FIG. 92.—CRETIN, TEN MONTHS OLD, LENGTH, 25 INCHES.



hernia, the fatty tumors, torpor and low temperature are sufficient to characterize cretinism. The mistake is sometimes made of confusing Mongolian idiocy with cretinism. The former may be recognized by the peculiar formation of the eyes and of the extremities, the hypermobility of the joints and the frequent association

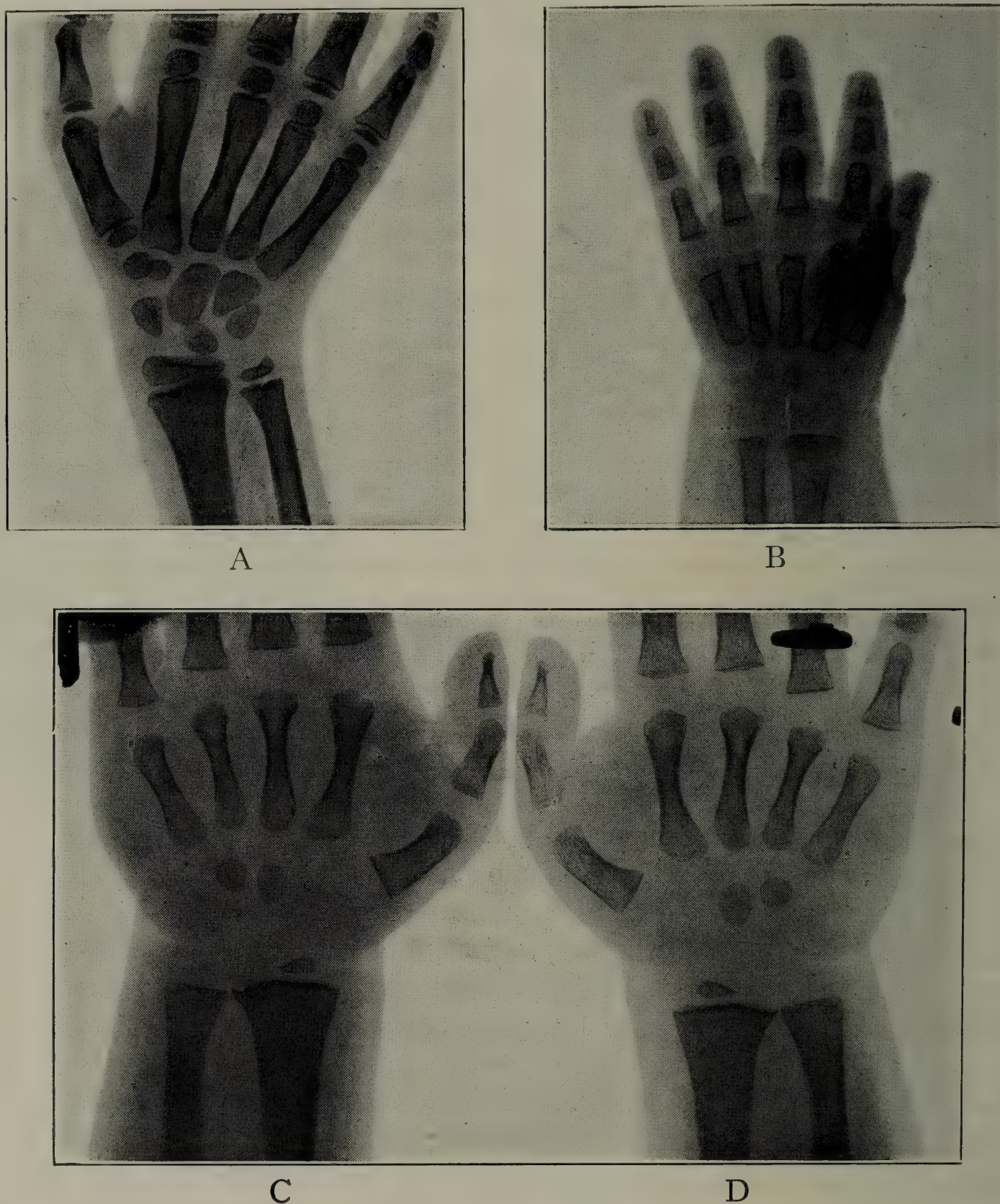


FIG. 93.—TWO NORMAL WRISTS AND WRISTS OF A CRETIN.

A, wrist of a normal child six years old. B, wrist of a normal infant six months old. C, and D, wrists of a cretin seven years old. There are only two carpal centers of ossification in the cretin at seven years, the same as in the infant of six months.

with congenital malformations of the heart. Mongolism, unlike cretinism, is present at birth; it does not cause retardation of ossification and rarely affects growth.

Individual symptoms of cretinism can be simulated by other conditions. The open mouth and protruding tongue may be found in macroglossia or in lymphangioma of the tongue. A dry skin may be due to ichthyosis. It is important to



consider the picture as a whole. The determination of basal metabolism is not generally available for the diagnosis of cretinism in infants. In cases where the diagnosis is doubtful the therapeutic test with thyroid extract is conclusive.

**Prognosis and Treatment.**—There is no tendency to spontaneous improvement. If untreated, cretins may live to an advanced age, but remain dwarfs, seldom attaining a height of more than three or three and a half feet. Their mental condition remains unimproved. Treatment with preparations of the thyroid gland brings about an extraordinary change. The preparation most used is the dried, powdered



FIG. 94.—A TYPICAL CRETIN, TWO AND A HALF YEARS OLD.



FIG. 95.—SAME PATIENT AT SIX AND ONE THIRD YEARS: EFFECT OF THYROID TREATMENT.

gland, usually called thyroid extract. It is quite as satisfactory as pure thyroxin, and is given by mouth. There is marked improvement in the constipation, and a subnormal temperature is no longer seen. After a few weeks' treatment the entire appearance of the child is changed. The idiotic expression of the face is lost; the thickening of the skin and subcutaneous tissues disappears; there is a marked increase in height and in the circumference of the head; muscular power is rapidly developed, so that many soon become able to walk; and progress is seen in dentition, and in some older girls in the establishment of menstruation. Intellectual progress is much slower than physical changes; however, nearly all the children become much brighter and more intelligent and learn to speak.

If treatment is begun early, physical development may be apparently normal,



but normal mental development we have not seen, even in cases in which treatment was begun during the first year. We have observed several cretins who have been treated from ten to fifteen years. Many of these children seem quite intelligent and are able to attend school, but without exception they are much below other children of their ages in mental and usually in physical development. Kerley has pointed out the uniform difficulty of treated cretins in coping with arithmetic.

As the condition of the gland is beyond hope of regeneration, these patients must continue taking thyroid extract as long as they live. If it is omitted symptoms begin to show themselves in a few weeks, even in cases well advanced toward recovery. Transplantation has been tried but has never been permanently or completely successful. As an initial dose a quarter of a grain (16 milligrams) may be given twice a day, the amount being gradually increased and the sustaining dose determined empirically. Warning of overdosage is seen in diarrhea, sweating, marked irritability, and sometimes a rise in temperature. The most effective results are obtained with a dose just insufficient to produce these symptoms.

### HYPOTHYROIDISM—INFANTILE MYXEDEMA

Cases of less outspoken thyroid deficiency are occasionally met with that differ from sporadic cretinism in the time of their development and in the severity

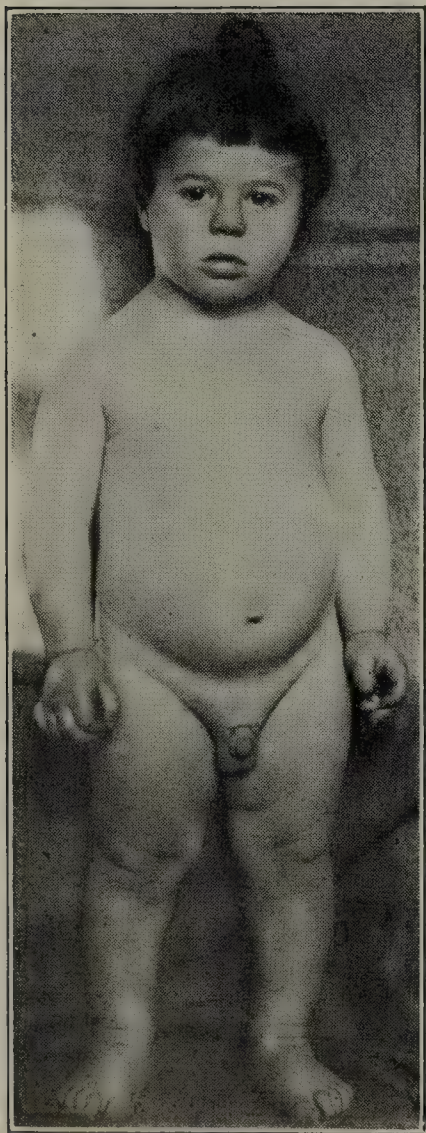


FIG. 96.—INFANTILE MYXEDEMA.

of the symptoms. Among them should be classed those cases closely resembling cretinism but not showing symptoms until the second or third year or even later, and then in only mild degree. The deficiency of the thyroid under such circumstances occurs in extra-uterine life or is incomplete. There are no pathological studies to show the condition of the gland, and the etiological factors causing its degeneration are unknown. In a certain number of instances the condition has followed some acute infectious disease. The symptoms are those that have been mentioned under sporadic cretinism, differing only in degree. It is usually the failure of mental or physical development that first attracts attention; the child is unable to learn, pays no attention to commands, is not cleanly in his habits, or he is much smaller than his fellows. More rarely he is noticed to have lost the ability to do things which he had formerly acquired. The height of these children is much below the average but the degree of dwarfism depends upon the time of onset of the thyroid deficiency. Some are greatly stunted, others less so, but normal growth does not occur and increase in height is very slight or absent. Roentgenograms as a rule show delayed ossification, which is especially noticeable in the carpal and tarsal centers of ossification and is proportional to the severity of the case. The facial expression

varies from the characteristic facies of cretinism to one that is only stupid or stolid. The lips are apt to be somewhat thickened, the tongue also, but by no means



always protruded. The hair is often coarse and generally thick. The children are usually well nourished, often stout. The skin is dry and thickened and the subcutaneous tissue firm. Fat pads are present in exceptional instances. The abdomen is usually large and in the more pronounced cases there is an umbilical hernia. In the less marked cases this is often lacking. The children readily complain of cold. Constipation is frequent but by no means the rule. Dentition is late and irregular and the second dentition delayed. The voice is usually deep and hoarse.

These children are quiet and placid. Their intelligence varies according to the severity of the disease. Some are imbecile, some have quite a high degree of intelligence, so that, though several years behind their fellows, they are able to attend school. In the marked cases it is hardly possible to err in diagnosis. The mild cases can only be determined positively by the effect of thyroid extract upon the symptoms and especially upon growth. Thus, in one of our cases aged three and a half years (Fig. 96) the height, which had been stationary for some months, increased nearly four inches in six months as the result of thyroid medication.

Treatment with thyroid brings about prompt improvement which will vary in extent according to the severity of the condition. Striking mental as well as physical improvement occurs. It is doubtful if complete intellectual development takes place. It is not to be expected that recovery of function in the diseased thyroid can occur. For this reason, thyroid extract should be given continuously. Mental and physical deterioration occur if its administration is interrupted.

## HYPERTHYROIDISM

Hyperthyroidism is not very common in children. When it does appear it is usually in a mild form. It is usually found in girls between the eighth and fifteenth years. Several children in the same family may suffer from the condition. The chief symptoms are restlessness, irritability and nervousness. The children are constantly active; they are apt to be emotionally unstable, and cry and laugh readily. They sleep badly and complain frequently of headache and of cardiac palpitation, especially upon exertion. Their appetite and digestion are usually good, but there may be for some weeks or months moderate loss of weight and strength. A mild degree of anemia is often present. Physical examination reveals in the majority of instances a slight enlargement of the thyroid gland, which does not pulsate. Exophthalmos, beyond a slight staring expression of the eyes, is not found, and von Stellwag's and von Graefe's signs are absent. The heart's action is slightly exaggerated and rapid. The hands of these children are apt to be constantly moist. The symptoms may last for some weeks or months. They usually disappear entirely, especially if proper measures are instituted, and in girls when menstruation becomes established. A marked increase in the severity of the symptoms is unusual, and the development of severe hyperthyroidism or Graves' disease from a mild form is rare. The treatment is largely hygienic—rest, quiet and removal from an overstimulating environment. Surgical measures are not called for.

Outspoken cases with exophthalmos (exophthalmic goiter or Graves' disease) are decidedly rare in children. We have seen one case in a girl of five years. As the age of puberty is approached these cases become more frequent. Girls are affected



three times as often as boys. The disease as it occurs in childhood differs chiefly in two respects from the type seen in adult life. The symptoms develop and disappear with much greater rapidity, perhaps even in the course of a few weeks, and the outlook with the child is much more favorable.

Attention is usually first called to the disease by restlessness and excitability or by the rapidity of the heart's action. Enlargement of the thyroid may not be evident at first but is regularly present at some time during the disease. The gland is generally uniformly enlarged, sometimes to a marked degree; it is firm, often hard, and can be felt to pulsate. With improvement in the symptoms there is a marked diminution in size, but a slight degree of permanent enlargement usually remains.

Exophthalmos is present in about four-fifths of the severe cases, and may even be extreme. The ocular signs of von Stellwag and von Graefe are both present in the majority of cases of this type. The fine tremor so commonly seen in adult patients is usually lacking. Involuntary movements, if present, are generally coarse incoördinate movements. The skin is often fine and moist. Perspiration is readily excited, and flushing is frequent. Pigmentation is not common. The heart's action is usually rapid and its violence is often complained of. A slight amount of cardiac dilatation may frequently be determined by physical examination. Nervousness is pronounced and is in most cases an early symptom. The children are constantly in motion and can be kept quiet only with difficulty. The first improvement is often noticed in a diminution of the restlessness. Appetite and digestion are usually excellent, but, as with adults, the increased metabolism which accompanies excessive thyroid activity causes loss of weight. Marked emaciation occasionally results.

The diarrhea, so troublesome a symptom with the adult form of the disease, is seldom marked. In general it may be said that the disease is milder than with adults and that its course is shorter. It may last only a few weeks but at times remains for several years.

The diagnosis offers few difficulties. Observations on basal metabolism can usually be made without difficulty on these patients and provide an excellent measure of severity and progress.

The prognosis is relatively good. The mortality from recorded cases has not been more than 10 per cent. There may remain indefinitely a slight degree of exophthalmos and enlargement of the thyroid and a tendency to cardiac palpitation with tachycardia. Permanent damage to the heart we have never observed.

The treatment should be directed toward securing, for a time at least, complete mental and physical rest. Everything tending to excite or irritate should be avoided. It is best to remove the child from contact with other children. Prolonged warm packs may assist in producing rest and in inducing sleep, which should be encouraged in every way. As the nervousness diminishes mild exercise may be indulged in, and according to the improvement of symptoms the normal regimen gradually may be resumed. Studies, school attendance and contact with other children should only be allowed after many weeks or months, and when a nearly normal condition has again been reached.

Surgical measures should be withheld as long as possible, particularly if the patient is near the age of puberty, at which time a readjustment of the endocrine



glands may occur. It may be necessary to operate, however, if medical treatment fails and the life of the patient seems to be endangered.

### SIMPLE GOITER

There are certain districts in the world in which simple hyperplasia of the thyroid gland (colloid goiter) is very common. These are chiefly mountainous districts such as the Himalayas, Carpathians, Alps, Pyrenees. In parts of the United States and Canada, along the St. Lawrence River and about the Great Lakes, in Minnesota and the Dakotas, simple goiter is exceedingly frequent. Animals in the same regions also have simple hyperplasia of the thyroid. This hyperplasia may be found in quite young children but is more marked shortly before and at the time of puberty. Girls are more frequently affected than boys. The enlargement may be just appreciable or it may constitute a symmetrical growth of considerable size. It practically never produces any pressure symptoms. Aside from the disfigurement, the importance of this hyperplasia is that from it carcinomatous changes are likely to develop. In goitrous regions there is also an increased incidence of deaf-mutism, cretinism and idiocy.

Intensive investigations in this country and on the continent of Europe have established the fact that simple hyperplasia of the thyroid is, in many instances at least, a deficiency condition. It results from nearly complete absence of iodine from the diet. Hyperplasia may be prevented in man and in animals by providing a small amount of iodine in the water or food. The hyperplasia may also be cured or diminished by the same method. Marine and Kimball found in Akron, Ohio, that about 50 per cent of the school children had simple goiter. They carried out a demonstration during two and a half years with the following results: Sodium iodide was given to children twice yearly in doses of 0.2 gram a day for ten days. Five of 2190 children thus treated developed thyroid enlargement. Of 2305 girls who did not receive iodide, 495 developed thyroid enlargement. Of 1182 pupils with thyroid enlargement who took the treatment, 773 were benefited; of 1049 untreated, 145 improved. It seems incontrovertible that iodine is of great value and should be used in all regions where thyroid enlargement is endemic.

Many suggestions have been made for treatment of communities: that iodine should be added to the water supply, that children should receive tablets containing iodine at school, that iodides should be added to table salt. Unless iodine is supplied in one of these ways it would seem advisable to give 2 grams (30 grains) of sodium iodide in divided doses twice a year, in the spring and autumn. Two and one-half grains of iodine per pound of table salt will accomplish the same purpose. Iodized table salt is now a familiar article of commerce. There are also many kinds of tablets and lozenges designed for the purpose of goiter prevention, which contain small quantities of iodine in palatable form.

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## CHAPTER LXIX

### DISEASES OF THE PARATHYROIDS

#### HYPOPARATHYROIDISM

A deficiency of the internal secretion of the parathyroid causes tetany with characteristic changes in the blood chemistry and in the calcium and phosphorus metabolism. In chronic cases that have lasted some years ectodermal changes may develop. The commonest of these is cataract, but loss of hair, defects of dental enamel, and brittle, ridged nails are also described. The blood calcium in parathyroid tetany is diminished and the inorganic phosphate markedly increased; the calcium-phosphorus product is always higher than in rachitic tetany. The excretion of calcium and phosphorus in the urine is diminished. Changes in the bones have not been described.

Nearly all of the cases of hypoparathyroidism have followed operations upon the thyroid gland in which parathyroid tissue has been accidentally removed. There can be little doubt, however, that spontaneous hypoparathyroidism occurs in children. Albright and Ellsworth studied such a case at the Johns Hopkins Hospital in a boy whose symptoms of tetany began at the age of eight years and who continued with remissions until the age of fourteen, when their observations were made. Others have reported hypoparathyroid tetany in infancy. In a case reported by Wernstedt only a single hypoplastic remnant of parathyroid tissue was found at autopsy.

The logical treatment for these cases is the injection of parathyroid hormone. Unfortunately a tolerance to this drug may develop, after which it fails to produce a response. One is then forced to rely on calcium therapy. Ergosterol is not satisfactory in these cases. Sometimes the patient becomes adapted to the condition and may continue for years exhibiting a low blood calcium and yet no clinical evidence of tetany.

#### HYPERPLASIA OF THE PARATHYROID GLANDS

Hyperplasia of the parathyroid glands is commonly found in rickets. As stated elsewhere this may be a compensatory phenomenon which prevents most children with rickets from developing tetany. Symptoms of hyperparathyroidism do not occur.

#### HYPERPARATHYROIDISM

The administration of parathyroid hormone to a normal individual is followed by certain definite chemical changes. There is a rise in serum calcium, a drop in serum phosphate and an increased excretion of calcium and phosphorus in the urine. Calcium and phosphorus are lost by the body, these elements being given up chiefly by the bones.



When hyperparathyroidism persists for a long time certain very definite changes in the bones occur. This condition occurs spontaneously and is known as *osteitis fibrosa cystica* (von Recklinghausen's disease of bone<sup>1</sup>). The characteristics of this condition have been well studied, even though it is rare. There is a generalized osteoporosis with lacunar resorption and abortive attempts at new bone formation; there is fibrosis of the bone marrow, and there are foci of osteitis often associated with masses of giant cells (osteoclastomata). Spontaneous fractures are common. Pain in the bones is a conspicuous symptom. Loss of weight may be extreme. The disease shows a striking tendency to metastatic calcification. Calculi may be found in the kidneys, the lungs, the myocardium and elsewhere. The changes in the calcium and phosphorus metabolism are similar to those caused by administration of parathyroid hormone: there is a high serum calcium; it may be 15 milligrams per 100 c.c. or more; the serum phosphate is definitely diminished and the urinary output of calcium is increased. In some instances a palpable parathyroid tumor can be felt in the neck, but this may be wanting.

Removal of the parathyroid mass when this is present, and, in case it cannot be found, removal of a normal parathyroid is followed by striking clinical improvement. Pains cease and the bone lesions decrease in size; there is marked improvement in the general health. The chemical findings tend to return to normal. Not infrequently the operation results in a temporary hypoparathyroidism and tetany develops. This may disappear after a few days or weeks.

A number of cases of this condition have now been described in children, most of them in older children ten to twelve years of age. The clinical diagnosis offers few difficulties and can readily be confirmed by a determination of the blood calcium.

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<sup>1</sup> Not to be confused with neurofibromatosis, which is also known as von Recklinghausen's disease.



## CHAPTER LXX

### DISORDERS OF THE INTERNAL SECRETION OF THE PANCREAS

#### DIABETES MELLITUS

Diabetes is an uncommon disease in children. Among 60,000 admissions to the wards and dispensary of the Harriet Lane Home 81 cases have been recognized, the youngest a boy of eleven months. Although the disease has been reported in infants as young as four months (Schippers, Kochmann), it is rare in infancy.

**Etiology.**—Heredity is an important predisposing factor; in about one-fourth of the cases a family history of the disease can be obtained. Although Joslin has emphasized the benign nature of cases in which diabetes is familial, there are notable exceptions to this; one of the severest diabetics we have seen gave a history of diabetes on both sides of the family. In a small proportion of cases, the disease follows acute infections. Instances have been reported following blows on the head or nervous shocks, but the association is probably a mere coincidence.

There is no special race or sex predilection. Overindulgence in sweets is common enough in normal children; there is no evidence that children who develop diabetes have been particularly addicted to it. It has been noted by several observers that children when they first develop diabetes are usually overweight and often overheight as well. Ladd has reported instances in which a striking increase in weight preceded the onset of the disease.

**Pathology.**—There are no characteristic morphologic changes in diabetes; only in rare cases have significant changes in the islet tissue been found. The diabetic pancreas contains normal amounts of insulin. Nevertheless the conclusion is almost inescapable that the disease is due to a lack of *available* insulin. The fact that insulin will completely rectify the disorder and the close analogy between experimental pancreatic diabetes and the human disease give strong support to this view. Whether other endocrine glands play a significant rôle is still uncertain.

**Pathological Physiology.**—A deficiency of insulin allows the blood sugar level to rise; when it reaches the renal threshold (160 to 220 milligrams per 100 c.c.) glucose appears in the urine. The mechanism by which insulin lowers the blood sugar is not known with certainty. According to the generally accepted view insulin catalyzes the oxidation of glucose and also its synthesis into glycogen. Interference with these functions would explain hyperglycemia. Recently the "overproduction theory" has come into prominence. According to this view insulin inhibits the conversion of protein and fat into glucose; a deficiency of insulin permits overproduction of glucose from these sources with accumulation in the blood. For a critical discussion of these views the reader is referred to special works on the subject.

A regular feature of diabetes is the production of ketone bodies; these are



formed from the incomplete oxidation of fats. According to the conventional view, "fats burn only in the flame of carbohydrates," and faulty oxidation of carbohydrate causes the ketosis. Ketosis may be regarded as being caused by an excess of *ketogenic factors* (chiefly fat) available for combustion over *antiketogenic factors* (carbohydrate and foodstuff convertible into carbohydrate). In any normal individual, ketosis can be produced by a suitable increase in the ketogenic factors in the diet and may be cleared up by increasing the proportion of antiketogenic factors. This relation has been expressed quantitatively by Shaffer and by Woodyatt (see page 106). Although their formulas do not enable one to predict with accuracy the level at which ketosis will appear, since the ketogenic-antiketogenic ratio required to do this varies in individuals and in conditions of health and disease, nevertheless these expressions have proved of great practical value. They furnish a convenient basis for comparing different diets, provided one keeps in mind the fact that their terms apply to the food factors actually burned, rather than those merely consumed in the diet.

Ketosis is responsible for other metabolic changes. When ketone bodies are produced in excess the various protective mechanisms against acidosis (see page 50) come into play. Large amounts of ammonia are produced, and fixed base is also drawn upon to assist in the excretion of these abnormal acids. The resulting electrolyte loss may lead to dehydration.

An obscure feature of diabetes is a rise in the blood lipoids; both the neutral fat and the cholesterol esters are affected. This does not occur in all cases, but a moderate increase is not uncommon; at times it may be marked. The increase in blood lipoids seems to bear no relation to the severity of the disease or to the degree of ketosis. Lipemia, a milky appearance of the serum, is often found when the blood fat is high, but cannot be taken as an index of the quantity present, since the degree of dispersion is a factor in its production.

Diabetic coma has not been satisfactorily explained. It may be due to the acetone bodies themselves, to the acidosis, or to the accompanying dehydration. There is reason to believe that no single one of these factors is entirely responsible, for treatment directed against any one of them alone is likely to fail.

**Symptoms.**—Diabetes may develop insidiously; it may be recognized by a routine urine examination or may escape attention until an exacerbation causes the sudden development of coma. In other instances the onset of the disease appears to be rapid; it can sometimes be dated within a few weeks. Loss of weight and fatigability are quite as common early symptoms as polydipsia and polyuria; a voracious appetite is unusual, more often there is anorexia. The loss of weight is very rapid in severe cases—as much as six or eight pounds in a month. Thirst may be extreme, several liters a day being consumed with a corresponding increase in the urinary output. Enuresis is common in young children and is sometimes the first symptom to attract attention.

The onset of coma is usually heralded by changes in the mental state, the patient becoming increasingly lethargic. Sometimes there is vomiting, abdominal pain, or digestive disturbance. The odor of acetone may be detected on the breath, and there are evidences of acidosis and dehydration. The face is flushed, the lips have a peculiar cherry-red appearance, the mouth is dry and perspiration is scanty;



loss of skin elasticity and hyperpnea may be prominent. A striking phenomenon is a fall of intra-ocular tension—the soft eyeball.

The diabetic child under successful treatment is symptom-free, grows and develops in the ordinary way, and is in all other respects a normal individual. While the patient as a whole thrives, the basic metabolic abnormality improves but slowly, if at all; on the other hand, it is subject to serious and sometimes precipitate aggravations, ushered in usually by infections, sometimes by therapeutic irregularities, including lapses from diet, and occasionally by emotional factors. So intimately bound up is the symptomatology of the disease with its therapy that the two can scarcely be discussed apart. In general, while it is true that no case is “complete”—since some evidence of endogenous insulin production can always be obtained—most cases in children are severe, or are likely to become so in the course of time.

**Diagnosis.**—Diabetes is most often overlooked because of neglect of urinary examinations in children. Not only polydipsia and polyuria but any case of obscure loss of weight should direct attention to the urine. Enuresis commencing suddenly should make one suspicious.

One should not be too hasty in making the diagnosis merely from a reducing test in the urine; to do this may cause unnecessary alarm. The reducing substance may not be glucose at all, in which case the urine will fail to give a fermentation test. Alimentary glycosuria and renal diabetes must be ruled out by blood sugar determinations. In both of these conditions the fasting blood sugar is within the normal limits (not over 120 milligrams per 100 c.c.). In the normal individual the oral administration of 1.75 grams of glucose per kilogram of body weight causes the blood sugar to rise to a maximum of 120 to 180 milligrams per 100 c.c. within an hour, the normal value being regained within two hours. In the diabetic the fasting sugar exceeds 140 milligrams; after oral ingestion of glucose it continues to rise for more than an hour and fails to return to the preceding level in two hours; the maximum exceeds 200 milligrams per 100 c.c. (See curves on page 123.) If the fasting blood sugar is high the diagnosis of diabetes is assured; a glucose tolerance test is unnecessary.

In coma it is obviously impractical to wait for fasting blood sugar determinations or fermentation tests on the urine. A strongly positive reducing test in the urine, or a blood sugar in excess of 200 milligrams, may be taken as presumptive evidence of diabetes and the patient treated accordingly.

**Treatment.**—The principles of treatment are the same as with adults. The diet must provide for the caloric requirements and be adequate from the nutritional standpoint, but must avoid ketosis. Not less than 15 per cent of the calories should be in the form of protein, but considerable latitude exists as to how the remaining calories are to be supplied. Satisfactory results have been obtained with high protein diets, high carbohydrate diets and diets so high in fat that the patient is on the verge of ketosis most of the time. We are inclined to think that there is no advantage in high protein diets; the specific dynamic action of this foodstuff increases the caloric requirements, adding to the physician's difficulties. We do not believe that it is wise to keep patients on the verge of ketosis, since the margin of safety between this state and coma is small; a slight loss of tolerance may precipi-



tate coma; this adds to the risk, particularly with patients who cannot be kept under close observation. For this reason it is our practice to avoid diets in which the Woodyatt ketogenic-antiketogenic ratio exceeds 1.5. Such a ratio is given by a diet in which the calories are distributed as protein 15 per cent, fat 72.5 per cent, carbohydrate 12.5 per cent. The average normal child receives approximately protein 15 per cent, fat 35 per cent, carbohydrate 50 per cent (ketogenic-antiketogenic ratio = 0.35). The optimum diet for diabetic children lies between these limits, and the present tendency is to use in most cases diets in which no special emphasis is placed on a high fat intake. One finds not infrequently that an increase in carbohydrate is not accompanied by a proportionate increase in the amount of insulin required; in occasional instances the actual quantity of insulin needed is even decreased. Apparently a high carbohydrate diet stimulates even the diabetic pancreas to greater activity, but whether such stimulation exercises any influence on the course of the disease is not known. A high carbohydrate diet diminishes the temptation to steal food; the child may eat as other children. Joslin believes that the risk of developing arteriosclerosis is decreased by giving a liberal allowance of carbohydrate. On the other hand, it is not always advisable to give as much as 50 per cent of the calories in the form of carbohydrate. We have gained the impression that in certain diabetics—usually the severe ones—such a high carbohydrate intake leads to an increased lability of the blood sugar level; insulin reactions and glycosuria occur more frequently and regulation becomes more difficult.

With infants and young children it is advisable to avoid high fat diets. Ketosis occurs more readily and there is also the danger of producing fat intolerance by a diet of this kind. Obesity and a marked elevation of the blood fat are also indications for reducing the proportion of fat in the diet.

The preliminary regulation of the noncomatose diabetic is best accomplished in a hospital, where blood sugar determinations are more conveniently made and the collection of urine specimens is likely to be more accurate; insulin shocks are more readily recognized and treated; hence one may proceed more rapidly than with ambulatory patients. The procedures used by different physicians vary widely; that which is given below we believe to be as satisfactory as any.

There are three variables to be dealt with: the diet, the insulin, the amount of exercise taken, and possibly a fourth, the emotional state. Exercise is controlled at the start by keeping the patient in bed; he is then given a diet of known composition upon which his behavior is studied and insulin added in amounts sufficient to make him sugar-free. A period of preliminary starvation is pointless. In choosing a preliminary diet the total calories are first determined on the basis of body weight. For most patients confined to bed the requirements are met by 70 to 80 per cent of the normal caloric standard for the patient's age and weight (see page 101).

The amount of protein to be given is next determined. Young patients require more protein in proportion to body weight than do older children or adults, but if 15 per cent of the calories are supplied in the form of protein, the protein intake will be adequate at any age. The rest of the diet may be so chosen that the calories are almost equally divided between carbohydrate and fat. This makes for a palatable variety of foods. Saccharine and so-called "diabetic foods" offer no advan-



tages. The diet so calculated is now translated into three nearly equal meals by means of a table of food values.

For example, a diabetic child weighing 33 pounds is to be regulated. The normal requirements (see page 102) for such a child would be 1320 calories per day. Seventy-five per cent of this (990 calories) would be suitable to begin with. Giving 15 per cent of these calories in the form of protein will mean a protein intake of 148 calories ( $\frac{148}{4} = 37$  grams protein). Of the remaining 842 calories half may be given as fat ( $\frac{421}{9} = 47$  grams fat) and the remaining half as carbohydrate ( $\frac{421}{4} = 105$  grams carbohydrate).

A suitable diet fulfilling these requirements would be as follows:

Meal	Protein, Grams	Fat, Grams	Carbohydrate, Grams
<i>Breakfast</i>			
Milk, 150 c.c. ....	5	5	7
Orange juice, 90 c.c. ....			9
1 egg ....	6	6	
Toast, 30 gms. ....	3		18
Butter, 4½ gms. ....		4½	
Total .....	14	15½	34
<i>Lunch</i>			
Crisp bacon, 2 slices ....	2½	4½	
Mashed potato, 60 gms. ....	2		12
Carrots, 50 gms. ....	½		3
Green peas, 30 gms. ....	½		5
Butter, 4½ gms. ....		4½	
Milk, 180 c.c. ....	6	6	8½
Apple sauce (with sugar), 60 gms. ...	1		8
Total .....	12½	15	36½
<i>Supper</i>			
Oatmeal (dry), 15 gms. ....	2½	1	10
Sugar, 2 gms. ....			2
Cream (10%), 30 gms. ....	1	6	1
Milk, 150 c.c. ....	5	5	7
Toast, 25 gms. ....	2½		15
Butter, 4½ gms. ....		4½	
Total .....	11	16½	35
DAILY TOTAL .....	37½	47	105½

The object of the trial diet is to determine how much glucose will appear in the urine and the hours at which this occurs, so that insulin may be given accordingly. Morning, afternoon, evening and night specimens of urine are collected separately. In severe cases it may be necessary to study the urine over shorter periods. A rough estimate of the amount of insulin required is 1 unit for every 2 grams of glucose in the urine. The relation is not an exact one, and this amount may produce hypoglycemic shock; hence with outpatients it is safer to begin the insulin more cautiously. One may safely give as a starting dose 5 units if



the Benedict's solution reduction yields a yellow color and 10 units for a red test.

The optimum time for giving insulin must be determined empirically. In most patients fifteen to thirty minutes before meals is the best interval; in others forty-five minutes is more satisfactory. We have seen one patient who had to have his insulin one and three-quarter hours before meals.

The preliminary regulation will require at the most a few days; by this time the insulin will have been increased until the patient is sugar-free at least for a part of the day. He can then be allowed up progressively, and the diet increased in accordance with the appetite. This will probably require a readjustment of the insulin dosage. Insulin shocks indicate the need of reducing the dose.

According to observations made by Brush at the Babies' Hospital, the recovery of tolerance which follows an acute infection or other upset takes a surprisingly uniform course. The impaired tolerance persists for a time at an almost constant level, during which period the patient may require large amounts of insulin, behaving like a severe diabetic. After from one to three weeks the tolerance begins to improve, a situation which is heralded by an increased number of insulin reactions. This improvement continues usually for two or three weeks until a new level of tolerance is reached, which persists for an indefinite period. Only when this last level has been attained is it possible to determine how severe the patient's diabetes really is. Patients may require as much as 40 or 60 units of insulin a day at the start, and yet ultimately, without change of diet, may adjust themselves perfectly on as little as 5 units a day.

In the mild case in which the tolerance is almost completely regained, glycosuria can often be controlled by a single daily injection of insulin before breakfast. Such cases offer no great difficulty to the physician. When regulation has been established control can usually be adequately maintained by qualitative examination of day and night urine specimens for sugar and acetone. If the insulin requirement is as low as 5 units a day, it can frequently be dispensed with entirely by means of a high fat diet. We believe, however, that it is preferable to use a more normal diet with a small amount of insulin.

The severe diabetic offers greater difficulties in regulation. Such patients are rarely sugar-free throughout the twenty-four hours; they oscillate between glycosuria and insulin shock. Large quantities of insulin are usually needed, and it must be given three or even four times a day. Sometimes frequent determinations of the blood sugar throughout the course of one entire day will enable one to time the insulin administration to better advantage. A difficulty commonly encountered is a tendency for marked hyperglycemia and spilling to develop in the early morning hours. To some extent this can be controlled by increasing the insulin of the evening meal, or by giving an additional dose at bedtime. In the severest cases, only a midnight dose of insulin will be effective. The newer preparations in which the action of insulin is delayed (*e.g.*, protamine insulinate) appear to be of particular benefit in controlling this situation.

The animal experiments of Allen were largely responsible for the view that glycosuria exercised a detrimental effect on the carbohydrate tolerance and must be avoided at all costs. Definite proof that this holds true for human diabetes has,



however, never been advanced. Although the question must still be regarded as an unsettled one, we believe that the present more lenient attitude toward glycosuria is quite justified. We do not share the extreme view that in order to avoid insulin shocks, patients should be kept on the edge of glycosuria all the time; but we believe that intermittent glycosuria need occasion no concern.

With our present knowledge, it is not possible to state any optimal diet suitable for all diabetic children, any more than can be done for normal children. The diet mentioned above (in which the calories are distributed as: protein 15 per cent; fat 42.5 per cent; carbohydrate 42.5 per cent) is a convenient one to start with, but there is no reason why it may not be varied according to the indications mentioned above, or even because of the child's appetite alone. Thus an occasional child is met with who seems more content when 20 per cent of the calories are supplied as protein; other children will show some preferences for higher or lower carbohydrate diets. On the whole, the best results have been obtained with diets which do not differ greatly from that of the average normal child.

In the administration of insulin the usual aseptic precautions must be observed. The site of injection must be varied, the same spot being used no more frequently than once a month. Failure to observe this may result in local atrophy of the subcutaneous fat, or in poor absorption, since some inflammation and cicatrization may follow the injection. Successive injections may be made at progressively lower points on the inner surface of one thigh and leg for a week, then on the outer surface and so on to insure variety. Strong pinching of the skin during insertion of the needle minimizes pain. Many children as young as six years of age can be taught how to take their own insulin, and indeed take pride in this achievement. The earlier this responsibility is thrown on the child, the less distressing for all parties does this aspect of the treatment become.

To be effective insulin must be given intramuscularly or subcutaneously. Intravenous use is indicated only in coma. Synthaline and other substitutes which can be given orally have not proved of value.

*Insulin Shocks.*—Insulin shocks occur at one time or another in every diabetic child. The level of the blood sugar at which symptoms develop is usually lower than in adults. Harrison found that most children developed symptoms only when the blood sugar fell below 40 milligrams per 100 c.c.; in one of his cases it fell as low as 28 milligrams without producing symptoms. Mild reactions are difficult to detect in young children, since one is not aided by subjective sensations. The most common early manifestations are pallor, weakness or dizziness, sweating, rapid pulse and lassitude. Changes in disposition may be observed; when the child is examined he may be fretful or highly emotional; reactions may cause night terrors. Older children may have epigastric discomfort, tremor or diplopia. With severe reactions there is semiconsciousness, paralysis, and often incontinence; the temperature may be subnormal. Unless treatment is promptly given, convulsions, coma and even death may supervene. Fatal reactions in children are very rare, however.

The symptoms respond promptly to the oral administration of 2 or 3 ounces of fruit juice or 2 or 3 teaspoonfuls of corn syrup or cane sugar. A school child should always take lump sugar or candy in his pocket to be used in such emer-



gencies. If the hypoglycemia has led to unconsciousness, sugar should be given by stomach tube or glucose intravenously. Epinephrine will often arouse the patient so that he can take the carbohydrate by mouth. Recovery from hypoglycemia after treatment is surprisingly prompt.

Insulin reactions are unpleasant. They should not be allowed to engender fear, but merely respect for the use of insulin. A change in diet or in the dose or time of insulin administration may be all that is required to set the matter right; the fault may be in the exercise taken. Sudden violent exercise should be prohibited, since this often causes hypoglycemic reactions; moderate exercise should be encouraged. The daily activity of the diabetic child is more difficult to regulate than that of the adult. It is desirable not to standardize it, but to meet the demands of normal exercise by adjustment of diet and insulin.

*Infections.*—Although patients vary greatly in their response to infections, some loss of tolerance is to be expected. Ambulant patients should be instructed to reduce their diet, avoid fats, and to seek medical advice at once. During the course of an infection more frequent urine and blood examinations will be necessary; larger doses of insulin will be required and it may have to be given more frequently.

*Diabetic coma*—for purposes of treatment any unconscious patient with ketosis and glycosuria may be considered diabetic—is a medical emergency of the first order. The formation of ketone bodies must be checked by giving insulin; acidosis and dehydration require prompt treatment. The patient must be made and kept warm. Food is withheld and insulin pushed until the hyperglycemia is under control. Much insulin may be required, since it is poorly utilized in coma. Comparatively small doses at frequent intervals are more effective than larger doses given infrequently. The drug should be given at first every half-hour in doses of 10 to 25 units; half the first dose may be given intravenously. There is no advantage in combining glucose with insulin when the blood sugar is above 250 milligrams or the urine shows a red Benedict's test. When the blood sugar is brought below this or the urine gives a less marked reduction, glucose should be given (2 grams per unit of insulin) in order to avoid hypoglycemia. This should be continued until coma has disappeared. Increase in the plasma carbon-dioxide combining power is an excellent criterion of the patient's progress, provided bicarbonate has not been given. As far as fluid and electrolyte balance is concerned, the situation is somewhat analogous to that of acidosis in infantile diarrhea (see page 181). Fixed base is lost by the body in the attempt to excrete ketone acids. Loss of electrolyte with dehydration impairs the renal function, causing further difficulty in excreting the ketone acids by this route. The indications are to restore water and electrolyte. Normal salt solution should be given at first intravenously, then intraperitoneally or subcutaneously until diuresis is established. If diuresis can be promptly established there is rarely need for alkali therapy; sodium chloride alone will usually meet the situation, the kidney excreting Cl and retaining Na until the fixed base deficit has been restored. Stimulants such as caffeine are sometimes beneficial.

The outcome in coma depends to a great extent upon the precipitating factor; coma associated with pneumonia is more difficult to treat than that brought on by a dietary indiscretion. As the coma disappears food may be started; it is well to



begin with carbohydrates. When the coma is gone, the patient may be returned to a maintenance diet.

**Complications.**—Pyogenic infections, particularly furunculosis, are common in diabetic patients, young or old. Other complications are infrequent in children, perhaps because many of them require considerable time for their development. Nearly all of the complications found in adults are occasionally met with—neuritis; cataract; pruritus, particularly of the genitalia; arteriosclerosis and gangrene. In our experience all these are rare. Transient albuminuria is not uncommon. A secondary anemia is a common finding, and should not be overlooked in treatment.

The treatment of diabetes in children involves considerably more than the treatment of the disease proper. Because of the serious consequences of infections of all kinds, every effort should be made to prevent them. All the protective inoculations which are of value should be given. A change of climate may be of great value in eliminating winter respiratory infections. Isolation of the patient from individuals with common colds and other diseases should be enforced. If there are foci of chronic infection, a more radical attitude should be taken than with a nondiabetic child. Anemia should receive appropriate treatment. Not the least important part of the treatment of the diabetic child are the psychological factors. One should never allow a child to become melancholy; sympathetic encouragement will carry him further than any amount of well-meant condolence. He should be educated as far as possible in the nature and treatment of the disease, and at the earliest possible moment he should be given the responsibility for his own welfare. Almost any child of ten can examine his urine and calculate and plan diets. This does not mean a break with medical supervision; questions of policy and the handling of emergencies still rest with the physician. The child should be encouraged to feel that success depends upon himself, rather than that he is being spied on. One must adopt a charitable attitude toward dietary indiscretions. As Joslin has expressed it, "Never ask a child if he has broken his diet, any more than you would ask a friend if he has been dishonest."

**Course and Prognosis.**—Before the discovery of insulin it was rare for diabetic children to survive more than a few months. By means of insulin it is possible to maintain them for an indefinite period in a state of normal health. Growth and development are not interfered with. However, the outlook for these patients is, on the whole, more serious than with adults, chiefly because of infections. Although some children are fortunate enough to acquire few infections, and some regain almost completely the tolerance lost with an infection, this is by no means the rule. With many the ground lost during an infection is only partially regained; with each succeeding infection the disease becomes more severe until eventually tolerance is almost completely lost.

A number of factors influence the prognosis in the individual case. Severe forms of the disease are less hopeful than mild ones. The response to any single infection is an indication of what may be expected in the future. The older the child the better the prognosis, for resistance to infections, and perhaps to their consequences as well, is acquired with age. Much depends upon the coöperation of the parents and of the patient himself, both in the treatment of the disease and in the prevention of infections.



### RENAL DIABETES

This condition, although in no sense a disease of the pancreas, is conveniently considered here.

Cases of so-called renal diabetes are occasionally met with in childhood. They are characterized by a lowered renal threshold for glucose, which is excreted in the urine at normal levels of blood sugar. If the renal threshold is as low as 100 milligrams per 100 c.c., glycosuria is continuous; if it is 120 or more, glycosuria is intermittent. Although this condition has sometimes been regarded as a precursor of true diabetes, there is no convincing evidence that this is so. Renal diabetes is a congenital abnormality which persists throughout life. It sometimes runs in families. If the loss of glucose in the urine is large, such patients may require additional calories to compensate for this. In other respects renal diabetes requires no treatment.

### HYPERINSULINISM

Hyperinsulinism in association with neoplasms of the islet cells, as occasionally seen in adults, has not been reported in children.

Cases have been reported in infants of diabetic mothers in which death took place a few days after birth with lowering of the blood sugar and symptoms of hypoglycemia. At autopsy the islands of Langerhans were increased in number and size. The probable explanation is that a compensatory hypertrophy of the infant's islet tissue takes place *in utero* to make up for the mother's insulin deficiency.

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## CHAPTER LXXI

### DISEASES OF THE PITUITARY BODY

Knowledge in regard to the functions of the pituitary body has increased rapidly in late years. This gland differs from other glands of internal secretion in that it produces a number of different hormones. Certain facts stand out clearly. The anterior lobe produces a hormone controlling the growth of the body. It also produces hormones which control the sexual development and the subsequent functioning of the reproductive apparatus. An oversecretion of the growth hormone gives rise to gigantism and acromegaly. Such conditions are almost unknown before puberty. Gigantism is largely the result of oversecretion of this hormone during adolescence, whereas acromegaly results if the condition develops in adult life. A deficiency of the anterior lobe growth hormone may occur in childhood, giving rise to symmetrical dwarfism, a condition which is described elsewhere. This is usually associated with failure or delay in sexual development. However, there is no exact parallelism between the retardation in somatic and sexual development, for the latter seems to be under the control of one or more anterior lobe hormones quite separate from the growth hormone. Precocious sexuality is occasionally the result of anterior lobe hyperactivity, although other endocrine glands are more likely to be responsible.

Two other syndromes are attributed to pituitary deficiency. In the first of these—the *Fröhlich syndrome*—there is adiposity, delayed sex development, increased sugar tolerance, and sometimes mental torpor. This condition is most often seen in boys, although it has been described in girls as well. The symptoms may be evident as early as the third or fourth year, but it becomes more common as puberty approaches. These boys develop a “feminine habitus.” The distribution of body fat resembles that of the female, the hips are broad, the voice remains soprano, they develop little hair on the chin and the pubic hair follows the female distribution. It is probable that in the Fröhlich syndrome the anterior lobe as well as the posterior lobe is involved. Treatment with endocrine preparations is unsatisfactory. The ultimate prognosis is not necessarily unfavorable. Often the condition progresses up to a certain point and then remains stationary. The mentality may be entirely normal and in spite of the feminine habitus a normal sex function may develop.

Another syndrome that has been attributed to posterior lobe deficiency is *diabetes insipidus*. This is described elsewhere. In spite of the fact that pituitrin will relieve this condition, strong evidence has been advanced that this disease is produced not by a pituitary lesion, but by a lesion in some neighboring structure. Complete removal of the pituitary has been accomplished without producing diabetes insipidus, and this condition has frequently been produced by injuries which spared the pituitary.



Although it is often stated that the pituitary syndromes—and especially Fröhlich's syndrome—are usually caused by neoplasms, this has not been our experience. We are inclined to agree with Engelbach, who states that 95 per cent of pituitary dystrophies are benign. The possibility of neoplasm must, however, be borne in mind.

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## CHAPTER LXXII

### DISEASES OF OTHER DUCTLESS GLANDS

**The Pineal Gland.**—Tumors of the pineal body have in rare instances been associated with precocious sexual development; all the recorded cases of pineal precocity have been in males. The great majority of tumors produce no such symptoms, and the function of this gland remains obscure. It is not an uncommon finding in adults to discover quite accidentally a calcified pineal body in an x-ray examination, associated with no symptoms whatsoever. We have met with this finding several times in children.

**Pluriglandular Syndromes.**—There can be no doubt that many of the endocrine glands are closely interrelated. Hormones from one may stimulate or repress the activity of another. In many of the disturbances that have been discussed in the foregoing pages, secondary changes no doubt occur in other glands of internal secretion. For example, precocious sexuality may occur with tumors of the adrenal cortex, the gonads, the pituitary or the pineal body, nor is it clear at the present time how all these glands are related.

Polyglandular disturbances have been held responsible for a number of poorly understood conditions, notably various forms of dwarfism and mongolism; in fact, nearly every obscure disease has been attributed at one time or another to a disturbance of the internal secretions.

Endocrine therapy has been widely used, almost invariably with unsatisfactory results. In the past there has been little possibility of harm, for most of the gland extracts in use were without potency. This state of affairs is rapidly changing, and with the many powerful hormones that are now available their indiscriminate use in obscure conditions has possibilities of harm.

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SECTION XII

DISEASES OF THE BONES AND JOINTS

CHAPTER LXXIII

DEVELOPMENT AND OSSIFICATION CENTERS OF THE BONES

By means of the x-ray the appearance and union of the various epiphyseal centers of ossification can be closely followed. This is a valuable method for studying growth. In cretinism and other forms of infantilism the development of the bones is delayed, and x-ray studies enable one to evaluate the effects of treatment. The normal pattern is a fairly constant one, and is given in the accompanying table.

TABLE XLII  
TIME OF APPEARANCE AND UNION OF OSSIFICATION CENTERS \*

Age	Centers Present	
At birth	All long bones, including metacarpals, metatarsals and phalanges Three primary centers of os coxae Calcaneus Talus Cuboid Head of humerus Lower epiphysis of femur Upper epiphysis of tibia	
	Appearance of	Union of
6 months	Capitatum and hamatum of carpus	
1 year	Head of femur Third cuneiform of tarsus	
2 years	Coracoid process of scapula Capitellum of humerus Lower epiphysis of radius Lower epiphyses of tibia and fibula First cuneiform of tarsus	
3 years	Os triquetrum Patella Second cuneiform of tarsus Heads of metacarpals, metatarsals and phalanges Navicular of tarsus	

\* Considerable variations from the times given are met with in normal individuals. The data given are compiled from Haret-Dariaux-Quénu, *Atlas de Radiographie Osseuse* (Masson & Cie., Paris, 1927); also Camp and Cilley, *Am. J. Roentgenol.*, 1931. 26: 905, and other sources.



Age	Appearance of	Union of
4 years	Os lunatum Great trochanter Upper epiphysis of fibula	
5 years	Medial epicondyle of humerus Upper epiphysis of radius	
6 years	Multangulum majus Multangulum minus Navicular (carpal)	Head with capitellum of humerus
7 years	Lower epiphysis of ulna	
8 years	Epiphysis of os calcis	Ischium and pubis
9 years	Chief center of olecranon Pisiform	
10 years	Trochlea of humerus	
11-12 years	Lateral epicondyle of humerus Lesser trochanter of femur	
13 years	.....	Epiphysis of calcaneus
14 years	.....	Primary centers of os coxae at acetabulum
15 years	Acromion and accessory coracoid epiphyses Secondary centers of os coxae	Trochlea of humerus Upper epiphysis of radius
16 years	Crest of ilium Angle of scapula Glenoid epiphysis of scapula	Coracoid Heads of metacarpals and phalanges of hand Olecranon
17 years	Sternal end of clavicle	Trochanters Metatarsals and tarsal phalanges Acromion
18-20 years	.....	Head and lower end of femur Head of humerus Lower and upper epiphyses of fibula and tibia Lower epiphyses of radius and ulna
20-25 years	.....	Angle of scapula Secondary centers of os coxae Crest of ilium Sternal end of clavicle

The retardation of growth in pathological conditions is not always a symmetrical one, but in most instances this is the case. For instance, a cretin whose chronological age is seven years may have the epiphyseal development of a normal child of three. The carpus is the most useful single location for studying bone development. In Table XLIII the probabilities of carpal ossification at different ages are expressed as percentages.

In our experience the great majority of infants show two carpal centers at eight months of age. The familiar rule that the number of carpal ossification centers should be the same as the age in years is not a close approximation to the truth.



TABLE XLIII  
OSSIFICATION OF CARPUS \*

	Birth	6 Mos.	1 Yr.	2 Yrs.	3 Yrs.	4 Yrs.	5 Yrs.	6 Yrs.
Os capitatum .....	20	75	100	100	100	100	100	100
Os hamatum .....	20	75	100	100	100	100	100	100
Os triquetrum .....			20	33	75	80	100	100
Os lunatum .....				22	25	50	80	100
Os multangulum majus ...					12	16	60	100
Os multangulum minus ..						16	60	100
Os naviculare .....							60	100

\* Tabulated from the data of Puyhaubert, *J. de l'anat. et de la physiol.*, 1913, 49: 119.

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## CHAPTER LXXIV

### CONGENITAL DISTURBANCES OF GROWTH

#### OSTEOGENESIS IMPERFECTA

Osteogenesis imperfecta (osteopsathyrosis, fragilitas ossium) is a rare affection. No special disease can be held responsible for it and the condition is not usually hereditary. It is at times found in certain families associated with a peculiar blue coloring of the sclerae, and in such circumstances is distinctly hereditary. In affected families those children with a tendency to fractures have blue sclerae, but not all the children have this weakness of the bones. The explanation of the association is not clear.

The changes in the bones are characteristic, involving those formed in membrane as well as those formed from cartilage. The cartilage itself is in no way affected, so that the growth of the bones in length is normal. The formation of bone, however, both from the periosteum and in the shaft, is greatly interfered with on account of deficient numbers and activity of the osteoblasts. The result is that the bony trabeculae are infrequent and small. Thus the bones are thin and very fragile. No changes have been demonstrated in any of the ductless glands.

The most striking feature of the disease is the fragility of the bones—the ease with which they undergo fracture. This takes place even in intra-uterine life, so that infants are at times born with forty or fifty fractures and with greatly distorted extremities (Fig. 97). The majority of children with osteogenesis imperfecta are born dead or die shortly after birth. The bones of the skull may be so slightly formed that the whole cranium is soft and of a parchment-like consistency, with widely separated sutures. As the result of the numerous intra-uterine fractures, distinct shortening of the extremities may have taken place. Thus there may be at birth a certain similarity to the configuration of chondrodystrophy. This shortening can also be made out by the



FIG. 97.—OSTEOGENESIS IMPERFECTA, WITH DEFORMITIES.



x-ray; but confusion of the two is impossible, for the density of the bones in osteogenesis imperfecta is always greatly diminished and multiple fractures are almost always in evidence. Any of the bones, including the ribs, may be fractured. The condition resembles rickets in the tendency to spontaneous fracture and in the lack of density of the bones, but the resemblance is a very superficial one. The characteristic changes at the epiphyseal line in rickets are not found in osteogenesis imperfecta, nor do the typical epiphyseal deformities occur in the former disease. In rickets the diameter of the bones is not decreased.



FIG. 98.—OSTEOGENESIS IMPERFECTA.

Roentgenograms of extremities, showing deformities due partly to fractures, partly to loss of rigidity of structure. The decrease in thickness of the long bones is well shown in B.

Those infants who survive continue to show fragility of the bones. Fracture sometimes occurs from ordinary handling which it is quite impossible to prevent, or in other instances only when a moderate degree of force is applied. The process of repair takes a normal course at first, with formation of a fibrous callus which in time becomes calcified; but its later conversion into bone is defective and there may be more or less shortening and deformity.

Besides these very marked congenital cases others are met with in which there is seen an abnormal fragility of bones, but with symptoms much less severe than those above described. Whether these cases have the same pathology is not entirely clear.



In these cases there are seen frequent fractures from slight traumatism, and often from none at all that is recognizable. Such patients may have several fractures each year during infancy and early childhood. In exceptional instances the fragility of the bones is only manifested after several years, so that there may be no suspicion of trouble until a number of fractures occur as the result of mild traumatism. Good union generally occurs, and in many cases in nearly a normal time. The course of these cases varies greatly. In some there is no tendency to improvement. In others, usually in the milder cases, as the children grow older the predisposition to fracture is much less evident and may entirely disappear.

A number of studies of the calcium and phosphorus metabolism have been made in osteogenesis imperfecta with uniformly normal findings. The condition does not respond to antirachitic or to any other form of treatment.

### CHONDRODYSTROPHY

Chondrodystrophy (achondroplasia) is a rather rare condition, often improperly called congenital or fetal rickets. It is the cause of some of the most marked examples of dwarfism known. It was recognized as an abnormality by the early

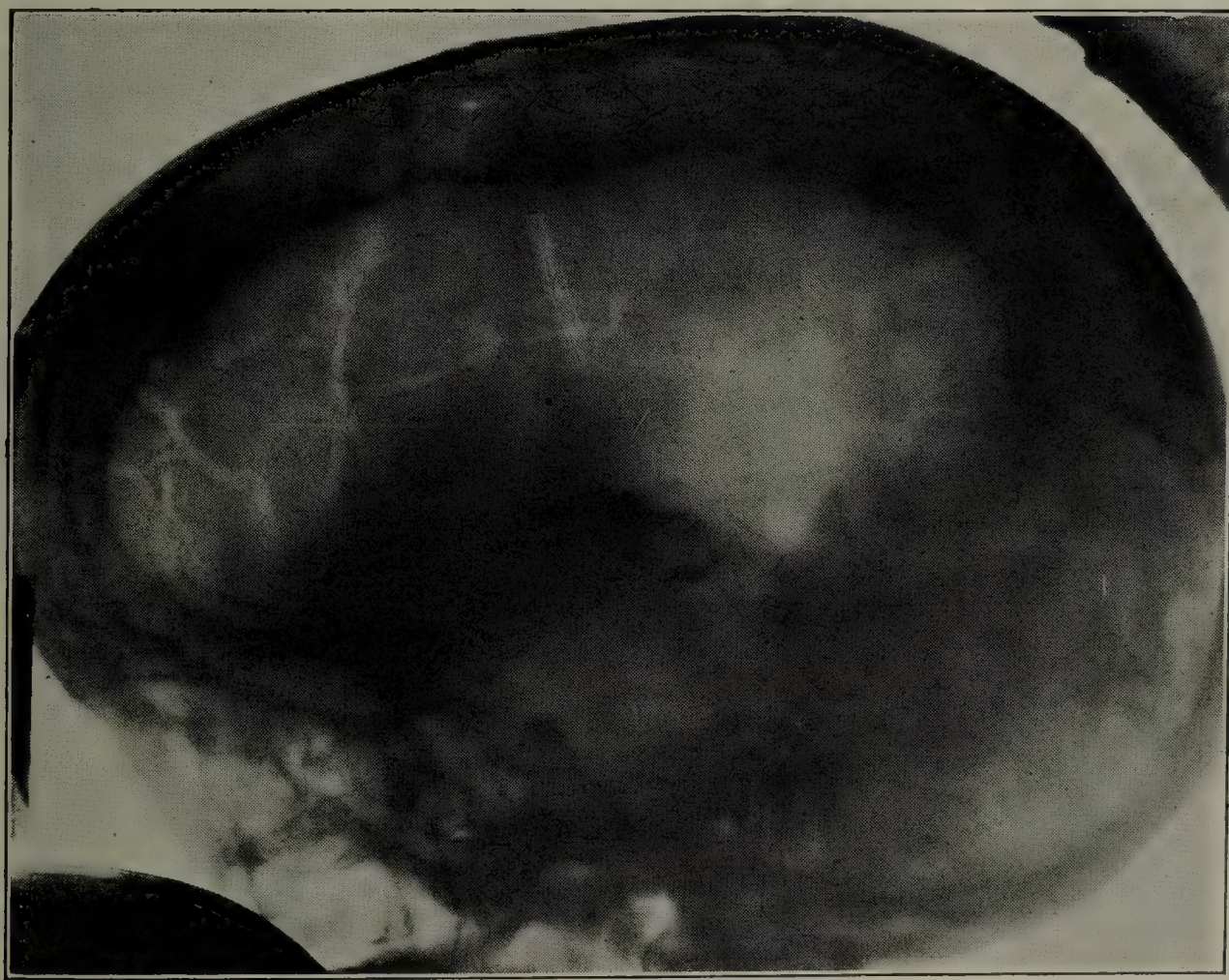


FIG. 99.—SKULL IN CHONDRODYSTROPHY, SHOWING HYDROCEPHALUS.  
Roentgenogram taken after the ventricles have been filled with air (Dandy).

Egyptians and has often figured in art since that date. Many of the old court jesters were of this type.

The causes of chondrodystrophy are unknown; only in rare cases has any hereditary connection been traced. We have seen a mother and child affected. The pathological process begins in fetal life and affects endochondral ossification only, causing marked interference with the growth of bones which are laid down in



cartilage. Intramembranous ossification is never affected; the flat bones, therefore, escape entirely. The vertebrae are only slightly affected, while the long bones of the extremities suffer most but not equally; the disturbance is usually symmetrical. The humeri and femora are almost always the seat of the greatest interference with growth. One of the most striking changes in the skull is the synostosis or early ossification of the tribasilar bone; this is formed of two parts of the sphenoid and the sphenoidal process of the occipital bone; unlike other cranial bones it is laid down in cartilage. Normally this ossification does not take place until adult life; in children with chondrodystrophy it often begins *in utero*. This prevents a normal expansion at the base of the skull, and the brain, as it grows, is thus

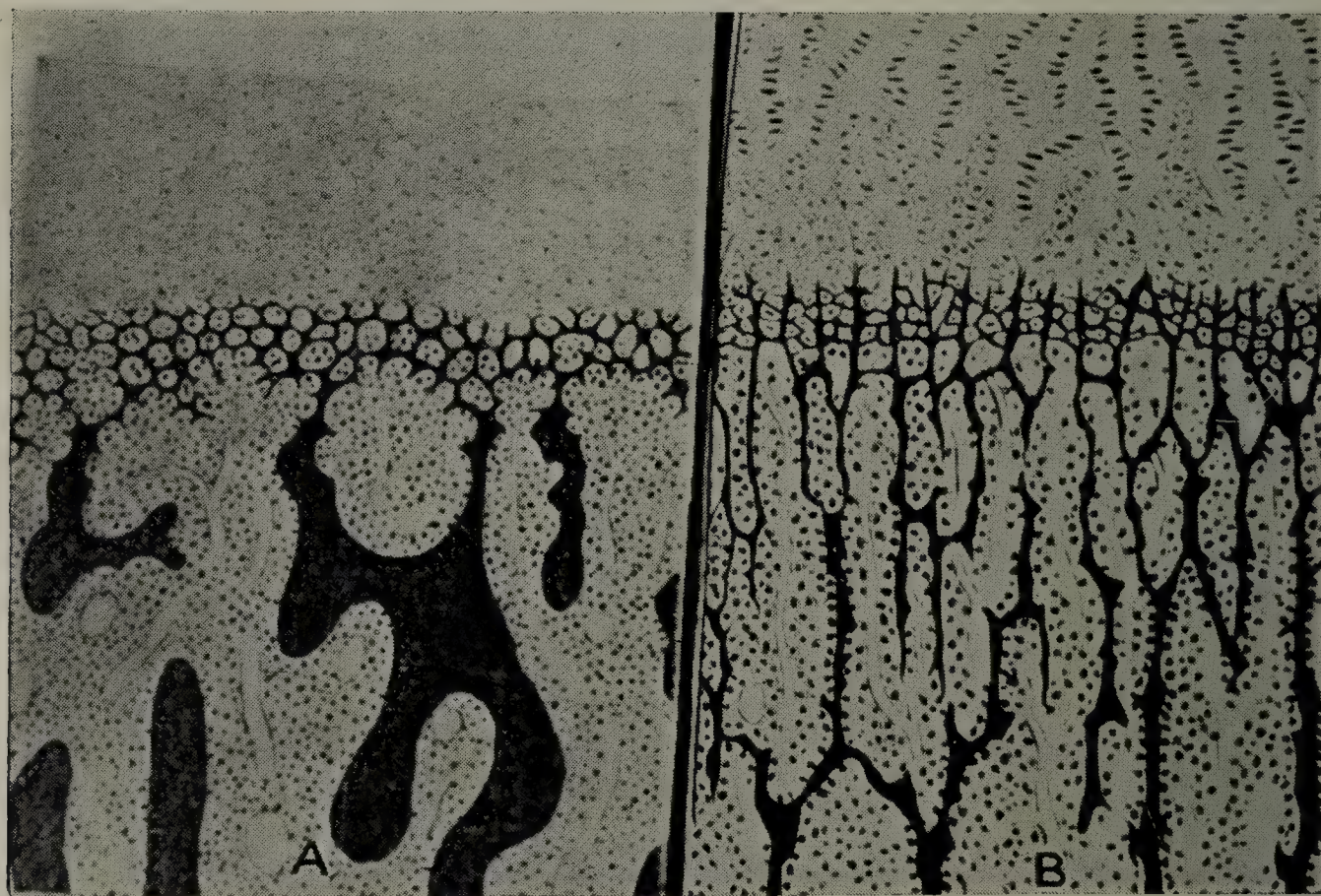


FIG. 100.—EPIPHYSEAL CHANGES IN CHONDRODYSTROPHY.

A, chondrodystrophy. B, normal.

crowded upward and forward, causing the great prominence of the forehead. There is frequently a moderate degree of hydrocephalus as is shown in Figure 99. The upper jaw appears prominent on account of the depression at the base of the nose.

The microscopic picture is characteristic, although it differs in degree in different subjects and in different bones in the same subject. The most striking changes are in the cartilage, changes in the bone itself being secondary. The layer of proliferative cartilage is very narrow; the cells mature in an irregular manner and fail to arrange themselves in orderly columns. Degenerative changes in the cells may be seen. The matrix has a coarse fibrillar appearance; calcification, however, is not interfered with and there forms a dense, distorted epiphyseal line. On the diaphyseal side of the epiphyseal line are found very irregular trabeculae. Abnormalities of the osteoblasts have been described (Lebedew). These changes are apparent only close to the epiphyseal line. The periosteum is not affected; here



ossification occurs normally and the bones increase in width out of all proportion to their length (Fig. 101). In some cases a periosteal lamella (the "encoche" of Ranvier) pushes inward between the epiphysis and diaphysis, still further restricting growth in length. A similar outgrowth at this point (*e.g.*, the transition point between periosteum and perichondrium) may occur, especially on the outer surface of the costo-chondral junctions, calcification of this mass giving rise to the "chondrodystrophic rosary."

**Symptoms.**—Many children suffering from this condition are either born dead or die shortly after birth. Those who survive are delicate during infancy, but afterward may become strong and healthy. The most striking thing about their appearance is the very short legs and arms as compared with the length of the body. At birth the arms in many cases do not reach to the iliac crests. The epiphyses appear somewhat enlarged; complete extension of the elbow is often impossible; knock knee is not uncommon. The abdomen is prominent, the skin of the extremities is in deep folds, the soft parts seeming to be much too abundant for the shortened bones. In infancy these

children are often quite fat. The facial expression is characteristic. There is usually a deep depression and flattening at the base of the nose, with a very marked prominence of the forehead. The large head is chiefly due, as Dandy has shown, to hydrocephalus, which, however, is seldom great. Dentition is slightly later than normal, but not more so than is seen in moderately severe rickets. Marked relaxation of the ligaments and rather feeble muscular power often delay walking until the third or fourth year; but in other cases it is normal or even precocious. If the head is large, the fontanel may not close till the fourth or fifth year. The so-called "trident hand" is characteristic. The fingers are short and of nearly equal length, and tend to diverge from each other (Fig. 103) at the second joint.

These dwarfs are usually somewhat subnormal in their mental development but cannot be classed as defectives. In fact there have been notable exceptions. They are good-natured, often amusing,

easily controlled, and frequently live to a great age. With advancing years the figure assumes a peculiar and characteristic appearance. The prominent hips, with

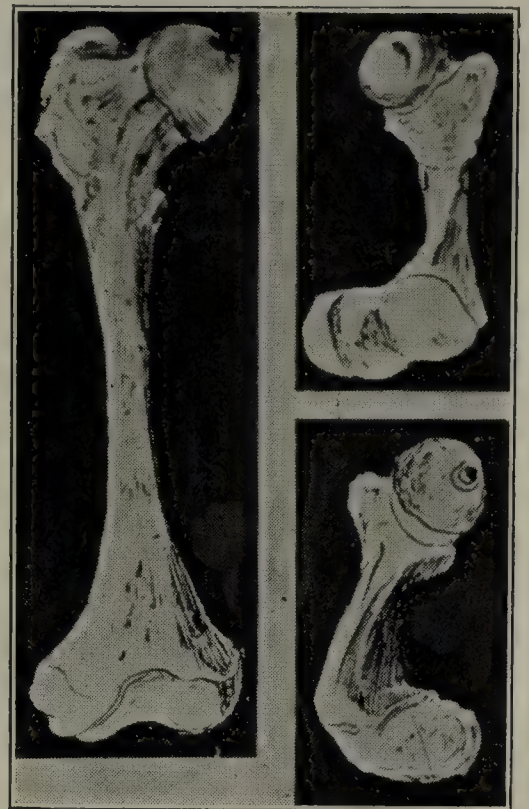


FIG. 101.—FEMORA IN CHONDRODYSTROPHY (RIGHT), COMPARED WITH A NORMAL FEMUR (LEFT).

The scale is the same for both.



FIG. 102.—A, NORMALLY DEVELOPED BOY, AGE EIGHT YEARS. B, TYPICAL CHONDRODYSTROPHY, AGE EIGHTEEN YEARS (MARIE).



the marked lordosis, shortened extremities, and late bowing of the legs, present a striking picture (Fig. 104). The maximum height attained is often not more



FIG. 103.—CHARACTERISTIC HAND OF CHONDRODYSTROPHY.

than three and a half feet. Although of feeble muscular power while young, later in life they often become very muscular. When adult life is reached the sexual powers are normal; if the women become pregnant, cesarean section is almost always required on account of deformity of the pelvis.

In infancy, chondrodystrophy is often confounded with rickets, cretinism and osteogenesis imperfecta, but its features are so characteristic that the mistake can hardly be made if the child is carefully examined. In severe osteogenesis imperfecta the femora may be very short but the association with multiple fractures determines the diagnosis. No known treatment has any influence upon the condition. Endocrine therapy is of no value.

### DWARFISM

Dwarfism includes all conditions characterized by stunting of growth. The term *nanism* is sometimes applied to conditions in which there is impairment of growth but not of maturation, whereas retardation of both growth and development is spoken of as *infantilism*. Many intermediate types are met with.

Dwarfism may result from diseases of the bone. Chondrodystrophy is the best example. The deformities of rickets, osteogenesis imperfecta or Pott's disease may result in a reduction of stature. Maturation is, however, rarely affected.

In cretinism, and to a less extent in other forms of hypothyroidism, retardation of both growth and development is seen. The characteristics of hypothyroidism are very definite and have been described elsewhere.

There remains a large group of so-called "symmetrical dwarfs" who do not show evidence of bone disease, nor any of the features of hypothyroidism. These are sometimes described as *infantilism of the Lorain type*. The clinical picture is not altogether uniform. In some instances the body proportions of the child are preserved and secondary sex characters fail to appear. The individual remains a child, although chronologically an adult. In other reported instances the individual develops the body proportions characteristic of the adult, including the sex characters. He is a miniature adult. Both of these extremes are very rare. It is much more common to find intermediate types in which, associated with a retardation of growth, there is a partial transition to the adult proportions. Secondary sex characteristics may develop some years after the usual time.

The cause of symmetrical dwarfism is variable. It may be due to a variety of chronic diseases which impair the general health, among which may be mentioned tuberculosis, syphilis, cardiac disease—especially in severe congenital malformations—cirrhosis of the liver and various drugs and poisons. The dwarfism is rarely extreme. Prolonged digestive disorders may produce higher degrees of dwarfism, such as celiac disease (*intestinal infantilism*) and lack of the external secretion of the pancreas (*pancreatic infantilism*). *Renal dwarfism* is a mixed condition. In



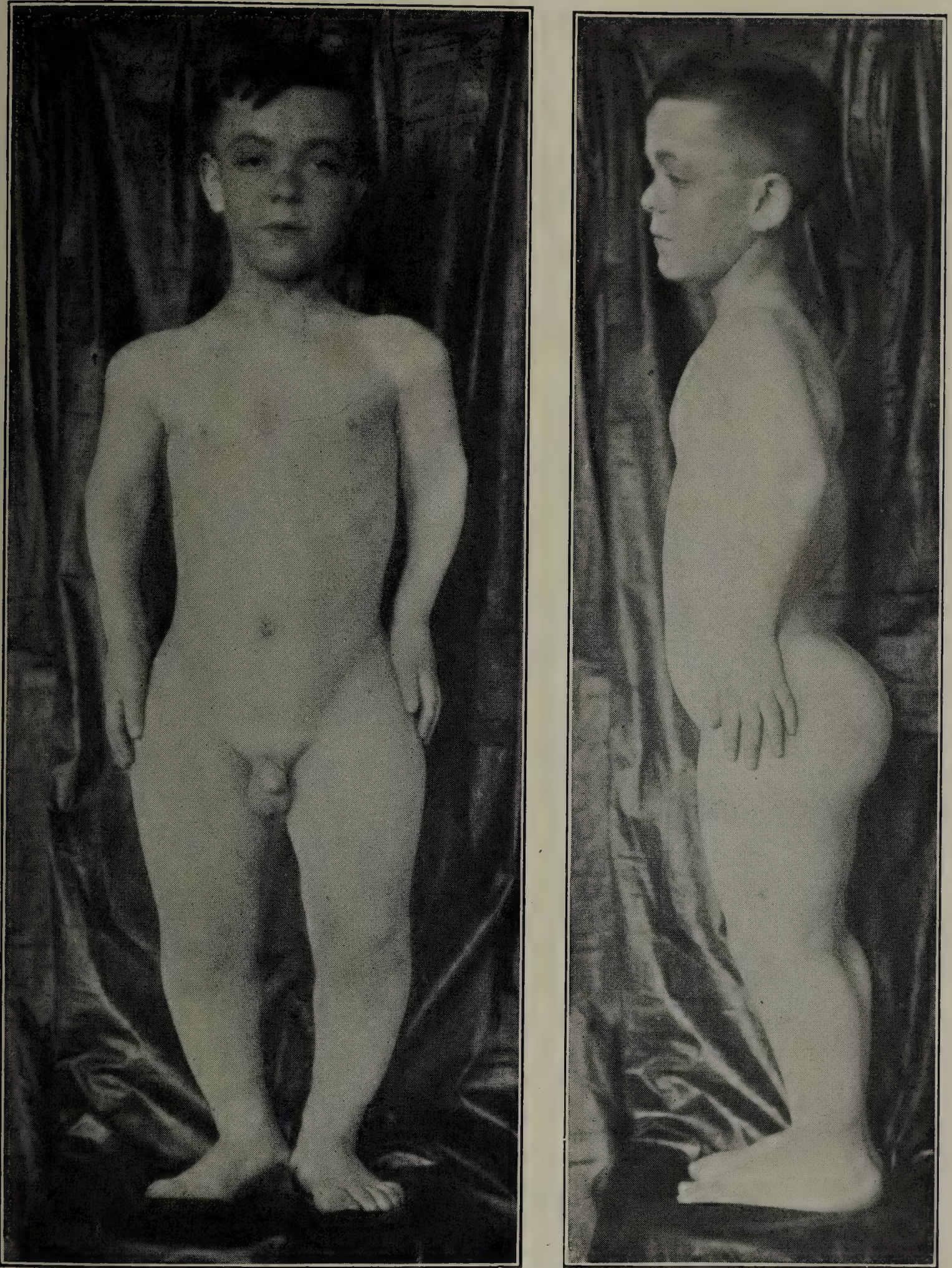


FIG. 104.—CHONDRODYSTROPHY.

addition to the general retardation of growth and development there are often changes in the bones resembling rickets (*renal rickets*).

Instances of symmetrical dwarfism are met with in which no etiological factor is evident. We have seen a number of such cases. This condition of essential or idiopathic dwarfism has been called *ateleiosis* by Gilford. It may be hereditary. Some of the smallest dwarfs on record have been of this type, but it is seen in all



degrees of severity. Such growth as these patients show is often discontinuous. There may be prolonged periods when it is almost at a complete standstill, followed by intervals in which growth is resumed at a rate only slightly below the normal. In recent years the belief has gained ground that most if not all of these ateleiotic dwarfs are caused by deficiency of the anterior pituitary growth hormone. Lesions of the pituitary may produce this picture. The condition is the opposite of gigantism. The term *pituitary infantilism*, which is often applied to these cases, is a confusing one, since other authors have used this term for the Fröhlich syndrome where growth is not retarded and infantilism is confined to the sexual characters. The Fröhlich syndrome is probably partly concerned with a posterior lobe deficiency.

Every case of symmetrical dwarfism should be thoroughly investigated for a possible cause—a chronic infection, a disorder of the digestive tract or a renal lesion. In some instances the primary cause can be eliminated, wholly or in part, and, if it is not too late, growth and development may be resumed. Endocrine therapy has not been attended with striking success either in the secondary or the idiopathic (pituitary) group of cases. Todd and Zook have studied a number of these cases, making detailed observations on the growth and maturation of the bones. By means of anterior pituitary preparations, they have been able to stimulate maturation of the bones, the appearance of new epiphyseal centers and union of centers already formed. Unfortunately, growth is only slightly stimulated if at all, and the treatment must be used with great caution, for to induce epiphyseal union limits such further spontaneous growth of bone as might occur.

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## CHAPTER LXXV

### CONGENITAL MALFORMATIONS

**Accessory Fontanels.**—These are not uncommon, occurring along the line of the sutures, most frequently in the sagittal and frontal sutures. They are usually small, close before the anterior fontanel, and are of no practical consequence.

**Acrocephaly (Oxycephaly).**—In this condition (Fig. 105), also called “steeple-head” or *Turmschädel*, the head is high and broad, with anteroposterior shortening. There is usually some degree of exophthalmos, and external strabismus is very common. The outer canthus may be lower than the inner. A number of patients are myopic, and any degree of optic atrophy may occur. The sense of



FIG. 105.—OXYCEPHALY WITH EXOPHTHALMOS AND PARTIAL BLINDNESS, WITH OPTIC NERVE ATROPHY IN CHILD TWO YEARS OLD.



FIG. 106.—SCAPHOCEPHALY IN INFANT SEVENTEEN MONTHS OLD.

smell is sometimes completely lost, though taste is rarely affected. Intelligence is as a rule unimpaired, and the deformity has no effect upon the duration of life. The condition apparently depends on premature synostosis of the frontal suture. It is usually hereditary; we have seen it in a mother and four children, not all in equal degree. Syndactylism and other deformities of the extremities are frequently associated (acrocephalosyndactylism).

**Scaphocephaly.**—Here the skull is narrow and elongated from before backwards, owing to early fusion of the sagittal suture. The hereditary element is not so strong as in acrocephaly, nor are associated visual disturbances and malformations of the extremities at all common. Some degree of hydrocephalus is likely to be found in either condition, but it is not progressive. These cranial deformities



seem to have no effect upon the duration of life. They are not amenable to treatment and the optic atrophy when present is usually progressive. It is possible that cerebral decompression may retard the optic changes but this has not yet been sufficiently employed to warrant a conclusion as to its influence.

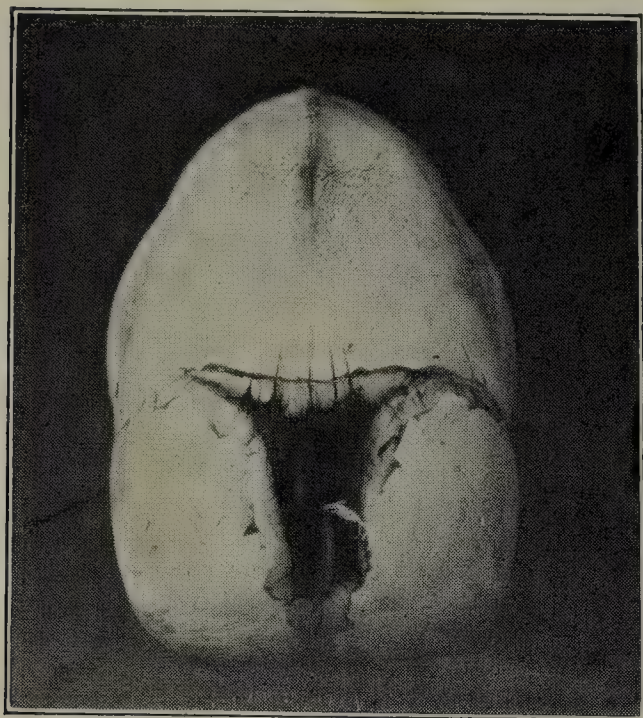


FIG. 107.—SCAPHOCEPHALY, SHOWING PREMATURE OSSIFICATION OF THE SAGITTAL SUTURE.

**Cleidocranial Dysostosis.**—This is a hereditary condition in which the fontanel remains open even to adult life and in which there is lack of union between the two portions of the clavicle, so that the shoulders can easily be brought together beneath the chin (Fig. 108). The mental faculties and general health are unimpaired.

**Polydactylism.**—Supernumerary digits are not uncommon. There may be anything from a mere nubbin of soft tissue to a complete digit with its own metacarpal or metatarsal bone. As many as eleven extra digits have been reported in one individual. The condition is strongly hereditary. Since these digits are usually without function, they are best removed.

**Syndactylism.**—Webbing quite commonly accompanies polydactylism; it is often found associated with acrocephaly, but it occurs also in otherwise normal individuals. Whether it requires surgical treatment depends mainly on its location and severity.

**Arachnodactylia.**—The hands and feet are abnormally long and slender. The fingers tend to be deflected to the ulnar side. Though the condition is often referred to as “spider fingers,” it is scarcely ever limited to the hands. There is usually considerable weakness of the grip and stance, and associated congenital malformations occur quite commonly. A hereditary factor is not always present.

**Congenital Absence of the Extremities.**—This may occur in any degree. Streeter has shown that the condition is a true developmental abnormality, rather than due to amputation by amniotic bands as was once taught.

**Phocomelia.**—This is a very rare condition, which may be hereditary, characterized by complete absence of the arms and legs, the hands and feet being attached directly to the shoulders and hips.

**Congenital Clubfoot and Clubhand.**—The former is much more common than the latter. It is often bilateral, and several forms and degrees are recognized. The association with spina bifida is discussed elsewhere (page 821). Early orthopedic treatment often effects a cure without resort to operation.

**Congenital Malformation of the Spine.**—Next to spina bifida, the commonest deformity of the spine is one which involves primarily the vertebral bodies and is often referred to as hemivertebra. In the course of embryonic development a portion of the spine, usually the middle and lower thoracic regions, splits into a double chain. Subsequent growth is not symmetrical in the two halves, and at successive levels one sees an attempt at mature development occurring now on one



side, now on the other, so that the final result is a jumble of malformed vertebrae quite out of line, usually with normal spine both above and below. The ribs share the confusion: there may be ten or eleven, or thirteen or fourteen ribs on one side, and fusion of ribs is almost always found, sometimes close to the spine, at other times anteriorly. Depending on the severity, there may be more or less shortening and curvature of the spine. Malformations in other parts of the body are sometimes associated. In most cases where the deformity is such as not to interfere with the function of the thoracic organs, the condition is quite compatible

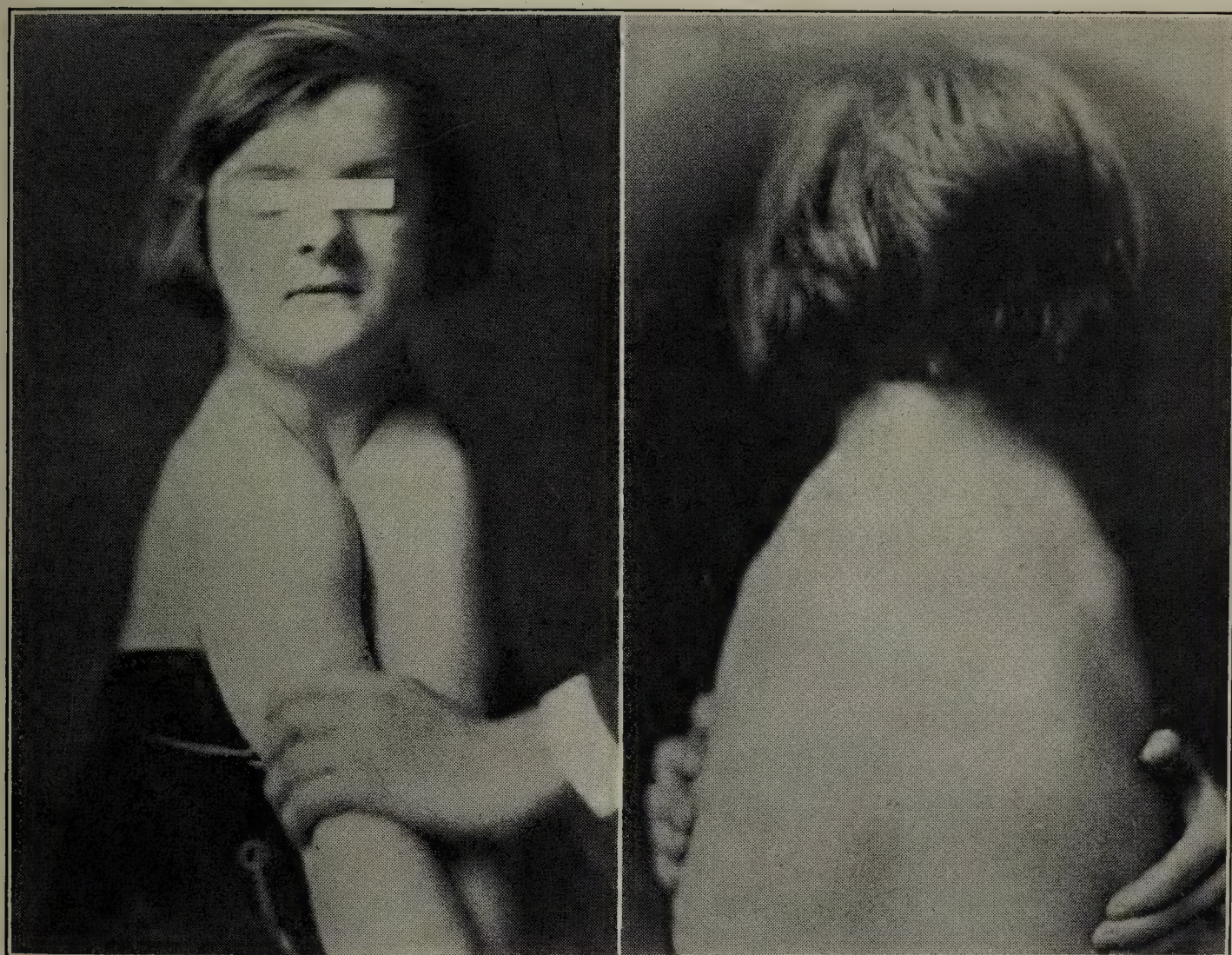


FIG. 108.—CLEIDOCRANIAL DYSOSTOSIS.

(Courtesy of Dr. R. W. Baer.)

with life and development to full maturity. As a rule there are no associated neurological signs such as in spina bifida, though weakness of the lower extremities and sphincter disturbances have been described. The condition is in many cases hereditary. There is no treatment.

**Congenital Dislocation of the Hip.**—This is by no means a rare anomaly. It is more common in females; in more than one-third of the cases it is bilateral. The treatment of this condition is an orthopedic problem, but its recognition, and particularly its early recognition—a matter of great importance—depends largely on the pediatrician.

The primary fault lies in a poor development of the upper margin of the acetabulum, as a result of which the head of the femur within its capsule is gradually displaced upward, coming to rest on the dorsum of the ilium. The head of the femur is smaller and flatter than normal. When the displacement has persisted the



old acetabular cavity becomes filled up with cartilage, fibrous tissue and fat; it is contracted, the edges are often undercut, and it may fail to admit the head of the femur at all. A false acetabulum may develop at the point where the head of the femur comes to rest.

Although the diagnosis is not often made before the age of walking, when attention is called to it by a limp or, in bilateral cases, by a peculiar waddling gait, it can be made much earlier by one who is familiar with its manifestations. The diagnosis has frequently been made as early as the fourth month, even without an x-ray.

When the dislocation is unilateral, there is shortening of the leg on the affected side and habitual outward rotation. There is apparent widening of the pelvis on the affected side. A change in the angle of the inguinal or the gluteal fold may call attention to the condition. On examination of the patient an abnormal mobility of the hip is found—especially in rotation. The diagnosis is confirmed by x-ray.

In bilateral dislocations, signs which depend on asymmetry are valueless and shortening is not likely to be detected. The most helpful early signs are habitual outward rotation of both legs and abnormal mobility. The pelvis is abnormally wide; when the child lies flat the space between the soft parts of the thighs is increased. Other signs are fullness of the trochanter and upward displacement of the trochanter above Nélaton's line. In children old enough to walk there is a peculiar waddling gait and an exaggerated lumbar lordosis. There may be vague pains and a disinclination to walk.

The only condition with which congenital dislocation is easily confused is coxa vara. This may cause a similar displacement of the trochanter, shortening and a similar gait. The earlier onset, the absence of rickets and the abnormal mobility are characteristic of congenital dislocation. The x-ray will remove all uncertainty.

The choice of treatment employed is a matter for the orthopedist to decide. In most cases that have persisted for two or three years an open operation is required. In younger subjects manipulation under anesthesia may be effective. Jaeger has recently reported excellent results in young subjects by splinting the leg in abduction, the head of the femur being gradually brought back into position by pressure applied over the trochanter.

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## CHAPTER LXXVI

### POSTNATAL DISTURBANCES

**Osteochondritis Deformans.**—This is an obscure condition of uncertain pathology, characterized by deformities of various bones which appear insidiously, absence of constitutional symptoms and a benign course, usually with complete healing. It is usually regarded as a low grade infection.

Occasionally the disease appears in several bones simultaneously, as in the patient reported by Wright, but as a rule only one bone is affected. The disease goes by different names according to its location—in the hip it is known as *Calvé-*



FIG. 109.—PERTHES' DISEASE.

Boy six years old; no symptoms or limitation of motion; tuberculin test negative.

*Legg-Perthes' disease*, in the tarsal scaphoid as *Koehler's disease*, in the tibial tubercle as *Osgood-Schlatter's disease*. It may affect the ischiopubic junction. Several other forms have been described.

It appears in children otherwise healthy, rarely before the fifth year. There is no conspicuous history of trauma. The disease will be described only as it affects the hip joint. This condition, sometimes known as *coxa plana*, begins insidiously with a limp. Local pain is never very severe, however. There is some limitation of abduction, but little or no adductor spasm. Shortening, if it occurs at all, is slight. Fever, local tenderness and leukocytosis are absent. The x-ray shows nothing at first, but soon a characteristic flattening of the epiphysis of the head of the



femur develops, from which the name *coxa plana* has been derived. Later on there is bony atrophy, and irregularity both of the epiphysis and of the acetabulum. There may be fragmentation of the head and thickening of the neck of the femur. The condition tends to subside spontaneously, the usual duration being from six to eighteen months. It does not recur. It is questionable if immobilizing the limb hastens recovery.

The chief importance of the disease lies in the fact that it can readily be mistaken for tuberculosis. The local symptoms are usually milder and constitutional symptoms are negligible. In most instances the x-ray findings make differentiation possible, but occasionally these are inconclusive. A negative tuberculin reaction may be of assistance. *Coxa plana* is usually seen between five and ten years of age, whereas bone tuberculosis is common between three and five years.

**Pulmonary Osteo-arthropathy.**—Although a distinction is sometimes made between this condition and simple clubbing of the fingers and toes (Hippocratic fingers), it is probably more correct to regard them both as different degrees of the same process. Clubbing occurs earlier and may be looked on as a mild degree of a disturbance which, when severe and prolonged, leads to periosteal new bone formation. It is found in association with congenital malformations of the heart, particularly those forms which produce cyanosis, occasionally in acquired carditis, in cirrhosis of the liver, and in long-standing suppurative conditions of the lungs and pleurae, especially empyema, lung abscess, chronic pneumonia both of tuberculous and nontuberculous origin, and in bronchiectasis. Occasionally it accompanies asthma, but only when there are organic changes in the lungs or bronchi. We have seen several well-developed instances in which no primary cause could be found. In most of the cases seen in childhood only the soft parts are involved. The nails increase in length and in both transverse and longitudinal convexity. The soft tissues spread out laterally (drumstick deformity) and the palmar fat pad increases in thickness. Usually all the digits are involved, though it is more noticeable in the fingers than in the toes. Clubbing has been observed as early as two weeks after the onset of the predisposing lesion. It usually subsides if the causative factor can be remedied; it may disappear, for example, a few weeks after the cure of empyema. There are no subjective sensations.

In cases that have persisted for years changes in the bones may appear; there is a tufting of the distal ends of the phalanges due to deposition of new bone from the periosteum. Changes in other long bones are described; they are uncommon in children.

**Flatfoot (pes valgus, fallen arch).**—The diagnosis of flatfoot is often erroneously made in young children. The development of the soft parts is such that the foot is nearly always flat when weight is put upon it; an impression of a footprint will reveal practically the entire sole. Moreover, children when they begin to walk tend to toe outward. This condition has been called "physiological flatfoot" and soon corrects itself as the muscles increase in strength. No treatment is required. After the age of three the normal foot tends to resemble that of the adult.

True flatfoot, however, is by no means uncommon. It may be congenital or may develop as the result of rickets or some other disease associated with muscular weakness. It may be the result of improper footwear. This is seldom difficult to



recognize. The patient often complains of fatigue or pain in the feet. In addition to the toeing-out, it is evident that the ankle is weak. The foot seems to have collapsed to some extent on the medial side; as the child stands, there is an abnormal amount of sole showing on the lateral side. The heel and sole of the shoe are more rapidly worn down on the inner side. The most characteristic manifestation is a "double" internal malleolus. Below the internal malleolus there appears another prominent bony mass—the talus.

Supports will remedy all but the most severe cases. A slight lift on the inner side of the sole may be all that is required. Rickets as a possible causative factor should always be kept in mind.

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CHAPTER LXXVII

ACUTE EPIPHYSITIS

(ACUTE ARTHRITIS; ACUTE OSTEOMYELITIS)

Pyogenic infections involving the joints and the adjacent bony structures are not uncommon in young children, especially during the first six months. Most of these cases are the result of a local infection which has resulted in sepsis. Those occurring in the first two months of life are usually due to an umbilical infection which may not have been manifest. Instances in older children may be associated with otitis, mastoiditis, empyema, or any local infection which has invaded the blood stream. Many cases occur as complications of infectious diseases like scarlet fever or typhoid. Trauma occasionally plays a part. Sometimes no source of the infection can be located. Gonococcus arthritis cannot always be traced to a urethritis; among 26 cases seen during an epidemic of vaginitis at the Babies' Hospital there were 19 cases of arthritis in boys none of whom showed any genital infection, and 7 cases in girls only 2 of whom had vaginitis.

The pathological process varies with the infecting organism. Thus gonococcus infections usually start in the joint cavity itself, whereas streptococcus, pneumococcus and staphylococcus infections usually start in the epiphysis or, more strictly speaking, in the metaphysis; the infection may then involve the joint secondarily or may spread into the diaphysis causing an osteomyelitis.

The frequency with which different organisms are responsible varies in different localities. Among 47 cases reported by Johnson from the Babies' Hospital the following incidence was found:

	<i>Cases</i>
Streptococcus .....	18
Pneumococcus .....	14
Gonococcus .....	7
Staphylococcus .....	3
B. influenzae .....	3
Meningococcus .....	1
B. coli .....	1

**Symptoms.**—The clinical picture is far from constant. Sometimes the condition develops slowly, often with few constitutional symptoms. This is particularly true of gonococcus arthritis. At other times the constitutional symptoms may be very severe and precede the local ones. The earliest local symptoms are pain and tenderness; there may be pseudoparalysis of an extremity, often with muscle spasm. Swelling and redness appear shortly and fluctuation may follow. Multiple lesions are by no means uncommon in severe infections with pyemia; they may appear simultaneously or follow one another. Gonococcus infections show a predilection for the small joints, in contrast to most other pyogenic bacteria, but this is



not an invariable rule. In Johnson's series the joints were involved with the following frequency:

	<i>Times</i>
Knee .....	27
Ankle .....	26
Wrist .....	25
Shoulder .....	24
Hip .....	17
Elbow .....	14
Metacarpo-phalangeal .....	12

**Diagnosis.**—Diagnostic difficulties seldom arise when constitutional symptoms are marked. Scurvy and syphilis may cause tenderness and pseudoparalysis; the former may cause marked swelling. The other manifestations of these diseases and their x-ray characteristics should eliminate any possible confusion. Gonococcus joints in older children may be mistaken for rheumatic fever. In doubtful cases culture and aspiration of the joint will settle the question. We have known anaphylactoid purpura (Schönlein's disease) to be confused with pyogenic arthritis. Tuberculosis occasionally gives rise to diagnostic difficulties. A rare mistake is to confuse a hemophilic joint with acute arthritis. We have known serious consequences to follow drainage in such instances.

**Treatment.**—There are many problems that arise in connection with treatment. When there are constitutional symptoms, local inflammation, and fluctuation about a joint the indications for aspiration are clear enough. Repeated aspiration with a needle is sometimes preferable to incision and open drainage. In no instance should a drain be left in the joint cavity. In early cases where there is epiphysitis which has not yet involved the joint cavity, the indications for treatment are not so clear. In some instances where there is local swelling and redness but no fluctuation the process subsides under conservative treatment with hot applications and the joint cavity is not involved. This outcome is unusual. In employing radical treatment one is influenced to some extent by the severity of the constitutional symptoms. We have seen several instances with marked constitutional symptoms in which no local suppuration could be made out, although there was marked redness and swelling. When an incision was made, at most only a drop or two of bloody pus was discovered. However, there followed prompt improvement in the constitutional symptoms and in the local condition. Immobilization of an infected joint or epiphysis is always desirable in order to limit the spread of the infection.

**Prognosis.**—The prognosis as to life in these infections depends on the general condition much more than on the local. A blood culture may give valuable prognostic information. The prognosis in regard to permanent local damage is variable. In most of the gonococcus cases recovery is complete. Many of the cases of arthritis due to other organisms recover completely with repeated aspiration, but in some of them ankylosis—partial or complete—occurs. Cases of acute epiphysitis drained before there is joint involvement often recover completely. There may, however, be permanent disorganization. In some instances there is separation of the epiphysis. Extensive destruction of the ligaments may result in a flail joint. There is always the possibility of a complicating osteomyelitis. In view of the



various complications that may develop, the prognosis as to the outcome of the local lesion should always be guarded. °

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## CHAPTER LXXVIII

### CHRONIC POLYARTHRITIS

(CHRONIC INFECTIOUS ARTHRITIS; RHEUMATOID ARTHRITIS; STILL'S DISEASE)

This condition is characterized by progressive involvement of a number of joints, usually in a symmetrical distribution; it runs a very chronic course with no tendency to suppuration. Still noted the frequency with which the condition is associated with enlargement of the spleen and lymph nodes; cases in which this is a conspicuous feature are often designated as Still's disease.

**Etiology.**—Not much is known regarding its causation. Cultures from the joints and blood have either been sterile or have yielded organisms which may well be suspected as contaminants. Dawson and Boots have found agglutinins to hemolytic streptococci commonly in their patients; they regard rheumatoid arthritis as the result of focal infection with these organisms. In some instances foci of infection have been found—in the teeth, the tonsils, the nasal sinuses or elsewhere. In most cases no such focus can be discovered. The elimination of obvious foci rarely produces striking results, and often has no effect whatever.

The relation of the disease to rheumatic fever has been much discussed. Although the course of the arthritis and the absence of chorea and cardiac manifestations in rheumatoid arthritis make it possible to draw a sharp clinical distinction between them, they possess a number of features in common. Subcutaneous nodules are occasionally met with in chronic arthritis which, according to Dawson and Boots, are indistinguishable histologically from those of acute rheumatic fever. Cutaneous manifestations may occur in chronic arthritis, such as erythemas, urticaria and even purpura. These phenomena suggest a possible relation between the two diseases, and give some justification for the use of the term "*rheumatoid arthritis*."

**Pathology.**—The lesions involve mainly the synovial membrane, joint capsule, ligaments, and surrounding structures. The synovial membrane is thickened and rough, and sometimes replaced by granulation tissue which may project into the joint cavity in large villous processes. Similar changes occur in the capsule. The joint fluid is only moderately increased in amount; it is usually clear. In cases of long standing, atrophy and erosion of the joint cartilages are found. The bones become porotic from atrophy quite early in the course, but as a rule show no other change even after months. Bony ankylosis is exceedingly rare. In a certain number of instances, changes in other viscera are found. The spleen and lymph nodes may be increased to several times their normal size, but they show nothing characteristic. The lesion is merely hyperplasia.

**Symptoms.**—The onset may be acute with fever and with involvement of the joints almost coincident with the fever, or there may be swelling and articular pain and tenderness with no fever whatever. At other times there may be fever



and other general symptoms for weeks before there are marked or definite articular symptoms. We have seen one boy who had fever for nearly three months before the involvement of his wrists, which was followed rapidly by that of his ankles and knees. The joints are usually symmetrically involved and many joints affected; shoulders, elbows, wrists and fingers, knees, ankles and feet in most of the cases, and less frequently those of the spine, jaw and the sternoclavicular articulation. The joints are moderately swollen and tender to the touch; on palpation they give a somewhat doughy sensation. They frequently contain a small amount of fluid which may disappear and reaccumulate. The appearance of the fingers is very characteristic, the first interphalangeal joint being the one earliest and most severely affected. The articular involvement causes flexion of the joints to a greater or less extent, and this deformity increases with the progress of the disease. The pain is not great, nor is there tenderness upon pressure, but attempts to bring the joints into their normal position by active or passive motion are impossible both on account of pain and the changes in the periarticular structures. The joints are often covered by fine, shiny skin. After the first few weeks or months there may be no fever whatever, and only the articular swellings. In other circumstances a continuous low fever may be present. There may be a persistent elevation of temperature, a degree or two above normal, or for weeks there may be daily exacerbations and remissions of several degrees. At times the fever disappears and may be absent for months, but when it has once been a feature of the disease it is likely to return. With the febrile form of arthritis there is usually enlargement of the superficial lymph nodes, chiefly the inguinal and axillary. The cervical glands may also be involved and not infrequently the epitrochlears. The spleen is often enlarged and rarely the liver also. There may be albuminuria and casts in the urine. There is usually a moderate degree of secondary anemia which is most marked in the febrile stages. A moderate leukocytosis often accompanies fever; occasionally eosinophilia is present. Dawson and Boots lay considerable emphasis on the increased erythrocyte sedimentation rate. There is a striking absence of cardiac complications such as are found in true rheumatic conditions. Subcutaneous nodules are far more rare in children than in rheumatic fever, but have been described by Still and others. Cutaneous symptoms are prominent with some patients. There may be frequent attacks of urticaria or erythema, sometimes erythema multiforme. Petechiae are extremely uncommon.

An examination with the x-ray shows a thickening of the periarticular structures, often distention of the joint, and a greater or less degree of osteoporosis. No osteophytes can be demonstrated.

The course is usually progressive for months, sometimes years. The crippling becomes greater and greater though the general health may remain quite good. Death, in such circumstances, is due to some intercurrent disease. Even when no cause for the disease can be discovered, spontaneous arrest not infrequently occurs. This may take place quite apart from the treatment employed and without evident reason. No case, therefore, should be considered hopeless. Total disability is rare.

**Treatment.**—This should always include a careful search for anything that might act as an etiological factor. Especially should septic processes in the tonsils,



the accessory sinuses and the teeth be sought and properly treated. Unfortunately in the great proportion of the cases no adequate cause can be found, and the treatment must be merely palliative. The patient should be placed under the best hygienic conditions and everything possible done to maintain the general nutrition. Removal to a warm, dry climate may be followed by very striking improvement. Since carditis is not to be feared, there is no indication for enforced rest; except during the febrile stages, most children do best when encouraged to as much activity as the local conditions in the joints will permit. Apparatus may be necessary to prevent deformity and to assist in walking.

In the control of symptoms the ordinary antirheumatic remedies are useless. Nonspecific protein shock therapy and transfusion have brought about improvement in some cases. Sympathectomy has occasionally been followed by local improvement. In one recent instance with which we are familiar removal of a markedly enlarged spleen was followed by arrest of the disease.

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## CHAPTER LXXIX

### NEOPLASMS

Neoplasms involving the bones are on the whole rare in children. Multiple enchondromata represent a developmental defect, often with a hereditary history; they involve predominantly the small bones of the hands and feet and may produce deformity interfering with function; if removed surgically, they usually recur. Multiple exostoses, even more rare, involve most frequently the bones about the knee, the upper end of the humerus, or the low end of the radius. Bone cysts have been reported in children. Some of these are associated with generalized osteitis fibrosa cystica (von Recklinghausen's disease of bone), which is discussed elsewhere. In other instances there is no evidence of a generalized metabolic disturbance and the osteitis is a purely local condition.

Primary malignant neoplasms arising in bone occasionally make their appearance in childhood. Osteogenic sarcoma develops usually in one of the long bones, more commonly perhaps in the lower end of the femur. We have seen one example of Ewing's tumor (endothelial myeloma) which began in the humerus of a boy six years of age. In both of these types of neoplasm a history of antecedent trauma is generally obtained, but the difficulty of evaluating its importance in pathogenesis is obvious; trauma directs attention to the bony swelling, which subsequently shows no tendency to subside. As a rule, pain is an inconstant accompaniment. The roentgenographic appearance of the involved bone may be sufficiently characteristic to differentiate neoplasm from osteomyelitis, but accurate diagnosis depends on the microscopic examination of material removed at biopsy. The treatment—whether surgical or radiotherapeutic—will likewise be governed by the estimated radiosensitivity of the type cell.

The one tumor of early life notorious for its tendency to metastasize to bone is adrenal neuroblastoma (see page 693); yet in instances of this type the masses which distort the contour of the skull are usually attached to the outside of the bones rather than infiltrating, and the x-ray shows merely a change in the soft parts. Patchy rarefaction and periosteal proliferation may be detected by roentgenogram in the bones of patients with acute leukemia, especially in those cases where "rheumatic" pains are complained of. Generalized xanthomatosis should not be overlooked as a possible cause of destructive lesions of the flat bones; it has been known to affect the long bones as well.

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## SECTION XIII

### DISEASES OF THE UROGENITAL SYSTEM

**Incidence.**—The following table gives the incidence of various urological conditions admitted to the wards of the Harriet Lane Home in Baltimore during a period of fourteen years. Cases of nephritis have not been included. With the exception of gonorrheal vaginitis, which was as a rule excluded, this may be taken as typical of the conditions likely to be met with by the pediatrician. Similar statistics

TABLE XLIV  
UROLOGIC DISEASES IN CHILDREN \*

	Total	Boys	Girls
Pyelonephritis .....	376	55	321
Pyonephrosis .....	2		
Pyelocystitis .....	151	24	127
Infarct of kidney .....	3		
Perinephric abscess .....	5		
Tuberculosis .....	9		
Renal calculus .....	2		
Hydronephrosis .....	13	12	1
Movable kidney .....	2		
Prolapse of kidney .....	4		
Polycystic kidney .....	4		
Horseshoe kidney .....	2		
Hypoplasia of kidney (congenital) .....	2		
Absence of kidney (congenital) .....	1		
Stricture of ureter .....	4		
Calculus, ureteral .....	1		
Enuresis .....	789	454	335
Neurological bladder .....	8		
Exstrophy of bladder .....	2		
Diverticulum of bladder .....	1		
Calculus, vesical .....	1		
Cyst of urachus .....	1		
Congenital obstruction of urethra .....	11	10	1
Gonorrheal urethritis .....	3		
Nonspecific urethritis .....	16	13	3
Hypospadias .....	41		
Undescended testicle, unilateral .....	53		
Undescended testicle, bilateral .....	14		
"Sarcoma" of testicle .....	1		
Teratoma of testicle .....	1		

\* From Young, *Practice of Urology*, Vol. II.



have been collected by H. L. Kretschmer and by M. F. Campbell. Urinary infections comprise 1 to 2 per cent of the cases seen in pediatric practice.

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## CHAPTER LXXX

## EXAMINATION OF THE GENITO-URINARY TRACT IN CHILDREN

**The Urine in Infancy and Childhood.**—Methods for the collection of urine are described elsewhere. The daily quantity is relatively greater than in older children or adults because of the relatively high fluid intake. The quantity varies greatly, depending upon the water ingested and the demands for its excretion by other routes. The following are average figures for healthy children:

<i>Age</i>	<i>Daily Quantity of Urine</i>
1 day .....	0— 60 c.c.
1 week .....	100— 250 c.c.
1 month .....	150— 400 c.c.
6 months .....	250— 500 c.c.
1 year .....	300— 600 c.c.
5 years .....	500—1000 c.c.
10 years .....	1000—1500 c.c.

The frequency of micturition in young infants while awake is often two or three times an hour; during sleep the urine is retained from two to six hours. At the age of two and one-half to three years the urine is held during sleep from eight to nine hours and at other times from two to three hours. Such control is sometimes attained at the age of two or even earlier. From slight nervous disturbances or minor ailments of any kind this control is impaired, and the urine may be passed by children of four or five years with the frequency seen in infants.

Voiding of urine does not always commence immediately after birth. Anuria lasting for twelve to twenty-four hours is not uncommon; it may last as long as thirty-six hours. In some cases this can be attributed to a difficulty of neuromuscular control; the bladder is palpable, and pressure upon the suprapubic region may start voiding. In other instances there appears to be a delay in urinary secretion, for the bladder is found to be empty. Such cases cannot be entirely explained by low fluid intake. There is definite evidence that the kidneys sometimes function even before birth. Urine may be found in the bladder of a stillborn infant.



The urine of the newly born child is likely to be concentrated because of the low fluid intake. It is usually highly colored and definitely acid in reaction. A moderate amount of albumin occurs in about one-third of all infants; sometimes casts are found. A relatively large amount of uric acid is secreted during the early days of life, the ratio of uric acid to urea being about 0.13 on the first day, and falling to 0.05 at the end of the first week.<sup>1</sup> The diapers often show a pink or reddish yellow stain from this substance. Urates and uric acid are conspicuous in the urinary sediment at this period, which also contains large numbers of epithelial cells and amorphous or crystalline bilirubin. These characteristics disappear after a few days.

The urine throughout infancy is pale, because of dilution. The specific gravity seldom rises above 1.010, but the infant's kidney is quite capable of concentrating, and readily does so in conditions of fever or dehydration. Throughout infancy small amounts of albumin are likely to be found when for any reason the urine becomes concentrated. Various sugars are likely to be found in the urine, not because the infant's kidney is more permeable, but because relatively larger quantities of sugar are likely to be fed. The different sugars vary as regards the amount which can be taken before renal elimination occurs. According to Grósz, lactose appears in the urine if more than 3 or 4 grams per kilogram are ingested; glycosuria occurs only after 5 grams of glucose or 7.7 grams of maltose per kilogram of body weight are taken. Creatinine occurs in the urine in relatively constant daily amounts which increase with age. A peculiarity of the infant's urine is the excretion of relatively large amount of creatine, which is found only in traces in older subjects. It would appear that this creatine is ingested with the milk, and does not represent a peculiarity of metabolism.

**Renal Function Tests in Early Life.**—The tests used with adults are all applicable to children. The phenolsulphonphthalein test is carried out exactly as with adults. Catheterization may be necessary to obtain the urine specimen at the end of two hours. Infants who have not developed control of the bladder can be kept on a bedpan throughout the period. Sufficient water should be given by mouth so that at least 75 c.c. of urine is voided during the two-hour period. The quantity of dye injected is the same for all ages; normally from 60 to 75 per cent is excreted in the two-hour period, if the dye has been given intravenously. When given intramuscularly, from 40 to 55 per cent is a normal figure, though much higher values are frequently encountered.

The concentration test of Mosenthal is likewise valuable in children. It is not necessary to collect voidings at regular intervals or to employ a particular diet as was originally advocated. Fixation of specific gravity at a high level is without significance, and usually means that insufficient water has been ingested to dilute the urine. With the exception of diabetes insipidus, fixation at a low level indicates serious renal damage.

**Nitrogen Retention.**—The values of the nonprotein nitrogenous constituents of the blood in children are the same as with adults. The following may be taken for normal fasting limits:

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<sup>1</sup> The adult ratio:  $\frac{\text{uric acid}}{\text{urea}}$  in urine is about 0.014.



	<i>Milligrams per 100 c.c.</i>
Nonprotein nitrogen .....	20-35
Urea nitrogen .....	12-20
Urea .....	26-43
Uric acid .....	1- 3
Creatinine .....	1- 2

*Urea Excretion Tests.*—Functional impairment of the kidney may be indicated by difficulty in the excretion of urea even before urea retention occurs. The *Ambard coefficient* and the *urea clearance test* of Van Slyke, which involve simultaneous determinations of blood urea and of the rate of urea excretion in urine, are probably the most sensitive tests of renal function we possess. These tests are, however, subject to definite limitations in children.

Different types of renal disease do not always affect these various functions similarly; thus in some instances there may be an impairment of urea excretion without loss of the ability to secrete dye, while in other cases the reverse may be true. It is therefore desirable to employ more than one functional test.

**Instrumentation of the Urinary Tract.**—It is now possible to carry out cystoscopy and ureteral catheterization even in newly born male infants. Instrumentation should not be attempted in young male infants, however, unless there is an urgent indication. In the case of congenital obstructions this is often a life-saving procedure. Cystoscopy may be required for diagnosis in persistent pyuria, unexplained hematuria, in certain disturbances of urination, when there is pain, or when there are abnormal masses in the genito-urinary tract.

*Intravenous urography* by means of iopax (uroselectan) or neoiopax has been a valuable addition to the methods of studying the urinary tract in infants and young children. In a large number of instances, but not invariably, entirely satisfactory pyelograms may be obtained. The procedure is apparently without risk and causes no irritation or discomfort.

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## CHAPTER LXXXI

### ANOMALIES OF URINARY EXCRETION

#### BENIGN ALBUMINURIA

If routine examinations of the urine are made, children are occasionally found who show a persistent excretion of albumin for some weeks at a time, unassociated with symptoms or with other signs of renal damage and not influenced by posture. The condition is usually not altered by changes in the diet. It is found to disappear spontaneously, but may occasionally recur. The cause is obscure. Albuminuria appears in certain children on exposure to cold, as after cold baths.

#### ORTHOSTATIC ALBUMINURIA

This condition, also known as postural, lordotic or cyclic albuminuria, although uncommon in young children, is frequently seen between the ages of six and fifteen years. It is slightly more common in males than in females. The majority of cases occur in children who stand with a considerable degree of lordosis. The condition is usually attributed to abnormal pressure on the renal veins, especially the left one, by the lumbar vertebrae which are displaced anteriorly when the patient assumes the lordotic position. It has been shown in experimental animals that pressure upon the renal vein will produce albuminuria.

**Symptoms.**—Some patients with orthostatic albuminuria are well nourished and have no other signs of disease; the majority, however, while they may be considered healthy, are not vigorous. They are often anemic and rather poorly nourished. They suffer from gastro-intestinal symptoms of which constipation is a frequent one and often have headaches and various neuroses. Cardiac palpitation and vasomotor symptoms are common. The trunk may be long in proportion to the height and the spine flexible. The abdomen is prominent. There are usually no symptoms that would direct attention to the genito-urinary tract and the condition is discovered in an attempt to explain the poor general condition of the patient.

The urine secreted while the child is lying down presents nothing abnormal. Shortly after assuming the upright position albumin appears in greater or less quantity. This is serum albumin plus a substance which is precipitated by acetic acid in the cold. The amount of albumin present may vary from a trace to 50 per cent by volume or even more. The substance precipitated by acetic acid, which is probably chondroitin sulphuric acid united with serum albumin, is never in large quantity. It causes clouding of the urine or an appreciable precipitate but no more. It is sometimes found alone and always when serum albumin is present. The assumption of a markedly lordotic position increases the albuminuria greatly. Infrequently casts may be present; they are usually hyaline casts and few in num-



ber. They may be associated with a temporary glycosuria; renal function tests, however, are entirely normal, nor is there any indication of nephritis.

It is important that orthostatic albuminuria should not be confused with nephritis. Children are not infrequently confined to bed for a long time and placed upon a rigid diet with the mistaken idea that nephritis is present. If, after repeated examinations, it is found that albumin is present only when the upright or lordotic position is assumed, if a substance precipitable by acetic acid in the cold is present, and other evidences of nephritis absent, the diagnosis of orthostatic albuminuria may properly be made. The substance precipitated by acetic acid in the cold is occasionally found in cases of true nephritis, but in smaller quantities.

Orthostatic albuminuria is a benign condition. It does not interfere with health. As a rule it disappears at or before puberty, but it may persist well into adult life. Rare instances are described in which a clear-cut postural albuminuria has eventually developed into a true chronic nephritis. Such an outcome is not to be expected.

**Treatment.**—Much can be done to prevent the albuminuria by attention to posture. The children should practice assuming a proper position in standing and sitting. Exercise is of value but prolonged standing should be avoided. If the lordosis persists in spite of these measures a light form of apparatus may be worn which prevents lordosis but does not interfere with exercise. Anemia, constipation and other associated conditions should receive appropriate treatment.

## HEMATURIA

Hematuria—the presence of red blood cells in urine—is to be distinguished from hemoglobinuria, where only blood pigment is present.

Hematuria may result from local or general causes. In the newly born it may be a manifestation of hemorrhagic disease or of sepsis; it is occasionally associated with the uric acid infarctions found at this age. Among the general causes seen in later childhood may be mentioned hemorrhagic diseases such as leukemia, purpura, hemophilia and scurvy. Acute hemorrhagic nephritis is commonly found in association with various infectious processes. Among the local causes encountered in early life one of the most common is balanitis resulting from diaper irritation. Trauma to the urinary tract or a calculus may be the cause of bleeding. It is believed by some that a concentrated urine may produce enough irritation to cause hematuria. Irritant drugs and urinary antiseptics like urotropin may cause vesical bleeding. Infections of the urinary tract occasionally give rise to hematuria; tuberculosis of the kidney, a common cause of bleeding in adults, is rare in children. In a small proportion of cases the hemorrhage is caused by a neoplasm, usually of the kidney.

In most cases of hematuria the amount of blood passed is small. When it is large it may appear in the urine as clear blood, or as clots, or it may impart simply a reddish or smoky color to the urine. The color, however, is not so reliable as a microscopic examination.

Large hemorrhages are much more likely to come from the kidneys than from the bladder. The presence of blood casts from the renal tubules, or larger ones from the ureter, is conclusive evidence of the renal origin of the hemorrhage. In



older children the two-glass test is often useful in locating the origin of the hemorrhage. If the bleeding comes from the kidney, the blood is equally distributed in both glasses.

The treatment of hematuria should be directed to the cause upon which it depends. In infancy scurvy especially should not be overlooked.

### PIGMENTS IN URINE

**Normal Pigments.**—Two pigments—urochrome and urobilin—are found in normal urine. The quantity of each shows variations under pathological conditions. The daily excretion of urochrome runs closely parallel to the total energy metabolism. In fever, and also in starvation, the elimination of this pigment is increased. Urochrome is largely responsible for the color of normal urine.

*Urobilin* occurs normally in small amounts. An excess is found in conditions of excessive blood destruction—hemolytic anemias, mismatched transfusions—and in certain types of liver disease.

*Bilirubin* is found in the urine in all types of jaundice; it may be detectable before the color of the skin and sclerae has appreciably changed. In icterus neonatorum, the amount of bilirubin in the urine is small and may be wanting altogether; this is attributed to a higher renal threshold for the excretion of this pigment in the first few days of life.

**Hemoglobinuria.**—In this condition blood pigment appears in the urine, but red blood cells are very few in number or are absent altogether. In severe cases the urine may be almost black. There is commonly a small amount of albumin. This condition may be recognized by the guaiac or benzidine test; the most conclusive means of diagnosis, however, is the spectroscope.

Epidemic hemoglobinuria (Winckel's disease) has already been described in the section on Diseases of the Newly Born. Hemoglobinuria may be due to certain poisons, as carbolic acid or potassium chlorate, or to certain infectious diseases, as scarlet fever, typhoid fever, malaria, syphilis, or erysipelas; or it may be due to mismatched transfusions.

*Paroxysmal hemoglobinuria* rarely occurs in childhood; it is found in late congenital syphilis. Paroxysms may be excited by exposure to cold, by chilling the surface of the body or by merely immersing the hands in cold water. Vigorous antiluetic treatment is indicated, and is usually successful in clearing up the condition.

**Other Pigments.**—Other abnormal pigments sometimes found in the urine are melanin, hematoporphyrin, anthocyanin (from beets) and certain dyes used in diagnosis and therapy.

### OTHER ABNORMAL SUBSTANCES IN URINE

A variety of abnormal substances, aside from pigments, may be found in the urine of children. Some of these are the result of abnormal articles of diet or medication, while others represent anomalies of metabolism which probably persist throughout life. The latter group includes conditions like cystinuria, alkaptonuria, pentosuria and others. These conditions are discussed in works on clinical microscopy and chemistry.



## DIABETES INSIPIDUS

This is a chronic disease characterized by polydipsia and the excretion of a large amount of pale urine of low specific gravity.

**Etiology.**—The disease is a comparatively rare one in children but may be met with at any age. It is somewhat more common in males. The Weils have cited remarkable examples of the disease existing in many members of the same family, but such a history is distinctly unusual. The association of diabetes insipidus with lesions at the base of the brain has long been observed—the lesion may be traumatic, a neoplasm, hydrocephalus or syphilis. Xanthomatosis of the Schüller-Christian type is a rare cause. The exact location of the lesion producing the disease is uncertain, but it is probably in the vicinity of the pituitary body. Although a lesion of the brain can be held responsible for the majority of cases of the disease, there are some which have been followed for years in which no cause whatever can be found. Sometimes the condition has followed one of the acute infectious diseases.

**Pathogenesis.**—The difficulty would seem to be a lowered renal threshold for water excretion rather than an inability of the kidneys to concentrate or a perverted appetite for water. In febrile states with marked loss of water through other channels, a concentrated urine may be secreted. Restriction of fluid intake diminishes the urinary output and causes a concentrated urine to be secreted, but a fluid intake which would be adequate for a normal individual causes these patients great thirst and may even lead to dehydration.

**Symptoms.**—The daily quantity of urine is enormous and may be from 2 to 10 liters a day. It is pale and of a specific gravity usually between 1.001 and 1.006, but presents no abnormalities. Often there is incontinence of urine. The bladder sometimes becomes enormously distended; in one of our cases it contained 1350 c.c. The skin is pale and dry and perspiration is scanty. Nervous symptoms are usually present; there may be disturbed sleep from the frequent micturition, palpitation, flushing of the face and other vasomotor phenomena, headache and restlessness. The general nutrition may not be much altered, but in some cases marked malnutrition develops. If the disease affects young children, their growth is generally retarded. Sometimes there is marked anorexia. A subnormal temperature is found in some of the cases.

**Course.**—The course of the disease is indefinite. Occasionally a patient will recover spontaneously. Usually the condition is chronic and lasts for many years. Many succumb in time to some form of brain disease which may not declare itself for a year or more after the onset of the diabetes insipidus. Few cases can be controlled without constant medication. Unless the symptoms can be controlled the nutrition continues to suffer and death may occur from some intercurrent infection.

**Diagnosis.**—This is easily made from the two marked symptoms, excessive thirst and polyuria. From diabetes mellitus it is easily distinguished by the low specific gravity and the absence of sugar from the urine. In older children, chronic nephritis with contracted kidney may be confounded with it. Its occasional association with syphilis should be remembered and a Wassermann test made as a



possible basis of treatment. The possibility of brain tumor must be investigated. Excessive water drinking from habit or caprice offers no difficulty in diagnosis.

**Treatment.**—Fluids should not be restricted. It is a serious mistake to reduce the quantity of fluids too much, since the drinking is not the cause of the diuresis. Symptomatic relief is always obtained from the hypodermic injection of  $\frac{1}{2}$  to 1 c.c. of pituitrin. Nasal instillation of liquid pituitrin or nasal insufflation of a powdered extract of posterior lobe is equally effective. Oral administration is impractical; enormous quantities must be given to obtain any effect. As a rule the drug causes no unpleasant symptoms, but in some instances abdominal cramps and manifestations of shock are met with. We have seen instances in which these could be avoided by nasal administration. The drug must be given once or twice a day, since the effect is only temporary; enough should be given to keep the patient comfortable. Unless an exciting cause, such as a brain tumor or syphilis, permits direct treatment the rest of the therapeutic program consists merely of general hygienic measures.

### ENURESIS

Incontinence of urine may be due to some malformation of the genito-urinary tract, such as a persistent urachus, an accessory ureter opening into the urethra, an abnormal opening from the bladder into the vagina, to exstrophy of the bladder, or defective innervation of the vesical sphincter. In such cases there is always continuous dribbling of urine; with persistent urachus, the urine is discharged from the umbilicus. Continuous dribbling may also result from a bladder which is distended because of an organic urethral obstruction or from various lesions of the nervous system; this is the so-called "overflow incontinence." The organic lesions of the nervous system which give rise to incontinence of urine are discussed elsewhere (neurological bladder). Here will be taken up only the functional cases of incontinence, to which the term enuresis is ordinarily applied.

The age at which a healthy child gains control of the bladder depends very much upon the training. It is possible to train some infants to control the bladder during waking hours before the end of the first year; the great majority acquire such control during the second year. If diurnal or nocturnal incontinence persists after the age of three, it may be regarded as pathological.

**Etiology.**—Enuresis may be due to a variety of causes which increase the irritability of the bladder. Psychic influences play an important part, involuntary voiding being precipitated by excitement, fear, rage or pain. In children with an inherited nervous constitution such factors are constantly at work. Incontinence is often associated with chorea and with various neuroses. In conditions of malnutrition and in fact with any acute illness, enuresis is likely to develop.

Reflex irritation of the bladder from a focus in the genito-urinary tract or in adjacent structures may be responsible for enuresis. In the bladder itself cystitis and vesical calculus should not be overlooked as possible causes. In some cases where enuresis has persisted for a long time the bladder becomes so contracted that it will hold only 50 to 100 c.c. of urine. This condition, although not the primary cause of incontinence, may be enough to continue it. A highly acid, concentrated urine, resulting from an insufficient intake of fluid, may be responsible. Among the local causes in neighboring organs may be mentioned balanitis, usually



associated with phimosis and preputial adhesions, vaginal irritation from vulvovaginitis or an adherent clitoris, and rectal irritation from pinworms, anal fissure or polyp.

In a certain number of cases incontinence is due merely to an excessively large amount of urine. This may result from the habit of drinking large amounts of water or from diseases such as diabetes mellitus or diabetes insipidus.

Probably the most important cause is habit, resulting from poor training. Habit is often a potent factor in continuing the incontinence, even after the primary cause has disappeared. Often no single factor is entirely responsible for the enuresis; it is the result of a combination of causes, no one of which alone would have been sufficient to produce it. Heredity is sometimes a factor; one may obtain a history of parents having suffered from the condition in childhood. There is no special sex predisposition. Enuresis is somewhat more common in cold weather, since less fluid is then likely to be excreted by the skin and more by the kidneys.

**Symptoms.**—Enuresis may be diurnal, nocturnal or both. It may be habitual or may occur only occasionally under the influence of some special exciting cause, when it continues until this cause is removed. In the majority of instances the condition persists from infancy until the sixth or seventh year, sometimes until puberty, but cases are common enough which begin suddenly after control has been obtained. Usually a cause can be found, but sometimes none is apparent.

**Diagnosis.**—In ordinary enuresis there is never dribbling of urine. If this occurs one may be certain that the condition has an organic basis. The difficulty lies in distinguishing the functional cases from those of so-called “neurological bladder,” in which only a weakness of the vesical sphincter is present. The differential diagnosis is discussed in connection with the latter condition. In our experience most of the doubtful cases have turned out to be functional in origin.

**Treatment.**—A child with enuresis should be thoroughly examined to determine if there is any organic disease that might be a factor in the situation. Local causes of irritation in the urinary tract or adjacent structures should be looked for and removed if possible. The urine should be examined for pus and sugar; a highly acid, concentrated urine with uric acid is in rare instances the cause of the difficulty and may constitute an indication for the more liberal use of fluids. A vesical calculus may be suspected if the enuresis is confined to the daytime and if there are evidences of painful micturition or straining. Sources of irritation about the external genitalia and the rectum should receive appropriate treatment. The fact remains, however, that only a small proportion of the cases of incontinence are relieved by such measures. For the great majority careful training is required before the condition is overcome.

Unless there is reason to believe that a concentrated highly acid urine is the cause of the difficulty, fluids should be restricted. Coffee and tea should be prohibited. For nocturnal enuresis no fluids should be given after 4 P.M., although they may be given freely before then. Semisolid foods, too, should be avoided at supper. Training should be begun during the day by voiding at regular intervals, which are gradually lengthened to accustom the bladder to distention. After the child goes to bed he should be awakened at regular hours to void. It may be necessary to do this every three hours throughout the night in order to keep the bed



dry. When he goes three hours without voiding the interval may be increased to three and a half and then to four hours. It is usually possible in this way to train a child in a few weeks to hold his urine with but one waking from 10 P.M. until morning; in a few months this can be omitted. It is surprising how many cases can be permanently cured if this regimen is faithfully carried out. Insufficient clothing at night is sometimes a cause of enuresis; water which would ordinarily be lost through the skin is secreted by the kidneys, increasing the urinary output.

Psychological factors are most important in the control of enuresis. Little can be accomplished unless the desire of the child himself to overcome the condition is aroused. Rewards are usually more efficacious than punishments. One should find out what the child desires most—a new doll, a bicycle, etc.—and allow him to have it if the bed is dry, taking it away if it is wet. The child's interest may be aroused by having him keep a record upon a calendar, gold stars being pasted upon the dates of dry nights. A financial honorarium for dry nights sometimes works marvels. Any measures that produce a marked impression upon the child's mind may be beneficial. Bad tasting drugs and mechanical measures such as the passing of sounds probably owe their occasional success to this factor. Sometimes the inspiring of confidence that the physician can bring about a cure is all that is needed. Hypnotism has been successfully used. An analysis of the home situation will often give the clue to a refractory case. The home environment may be such that the child is kept in an excitable state much of the time. Enuresis may be an expression of a desire to attract attention, or to obtain maternal solicitude; the underlying difficulty may be jealousy of a younger member of the family who is receiving more attention. In one instance with which we are familiar the habit of enuresis had persisted in a twelve-year-old girl who in consequence had remained very much tied to her mother's apron strings and had never been allowed to sleep away from home. Upon the physician's advice she was allowed to make a much desired visit to a friend; the enuresis disappeared and never recurred.

**Prognosis.**—Most cases of enuresis can be successfully treated. The results in the individual case will depend almost entirely upon the degree of coöperation that can be obtained from the child himself and from the parents. Drugs are of little assistance in treating the condition. Some success is claimed for atropine given in full doses, but in our experience this has been disappointing unless it is combined with other measures. The most difficult cases are those of long standing in older children; some of these resist all efforts and finally cease spontaneously about puberty; it is rare for the condition to continue beyond this period unless an organic neurological condition is at the basis of it.

The following case illustrates an instance in which purely psychological factors were responsible for enuresis.

A boy, four years of age, previously trained in control of urine and stools, began to have nocturnal and diurnal enuresis which persisted in spite of all ordinary measures. After two months there began occasional soiling with stool, which became increasingly frequent. There was at that time a younger brother of eighteen months, who seemed brighter and more appealing than the older boy. The mother admitted that she was more fond of the younger child and that various manifestations of jealousy on the part of the older boy had occurred. Explanation of the situation and intelligent coöperation



on the part of the mother, seemingly neglecting the younger boy and favoring the older by allowing him to remain up later in the evening with reading and games at this time, resulted in complete cessation of the symptoms. These recurred six months later during a critical illness of the younger boy, when he again became the center of attention. They cleared up a second time on recovery of the younger child.

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## CHAPTER LXXXII

### NEUROLOGICAL BLADDER

Disturbance in the function of the bladder resulting from lesions in the nervous system is rare in childhood. Among the more common causes of paralysis of the bladder are spina bifida, either of the external or of the occult variety, trauma of the spinal cord as a result of injury at birth in breech delivery, and poliomyelitis; it is a rare manifestation of neurosyphilis, and has been observed with neoplasms of the cord as well as in transverse myelitis following infectious disease. Young described a case caused by a broken lumbar puncture needle.

Two types are met with, depending upon whether the detrusor mechanism of the bladder or the sphincter is chiefly involved. In the majority of cases both elements are at fault; sympathetic imbalance gives rise to sphincter spasm with detrusor relaxation.

With impairment of the detrusor function there is difficulty in emptying the bladder and a variable amount of residual urine. When the condition develops acutely, there may be complete retention followed by overflow incontinence. If such patients are fortunate enough to escape catheterization, automatic voiding usually begins within a week and after a few weeks the bladder may be emptying itself almost completely. Some control over voiding may be obtained by training the abdominal muscles. If the amount of residual urine is small, such cases may go on for years; there is always the danger of infection, however, and the possibility of hydro-ureter and hydronephrosis. In the presence of stasis, instrumentation is almost certain to produce a permanent infection, with ultimate termination in pyonephrosis. On the other hand, without instrumentation the patient may succumb to uremia.

In the type with relaxed vesical sphincter, there is more or less continuous dribbling, and a bladder of small capacity with no residual urine. The relaxed vesical sphincter can be observed with an endoscope. There may be associated incontinence of feces, or perhaps only a relaxed anal sphincter. There is less danger of ascending infection than in the cases of sphincter spasm. The condition is seen in all degrees from complete sphincter paralysis to only a slight weakness.

The amount of sensory disturbance is variable, depending upon the neurological lesion.

We have records of 12 cases associated with spina bifida, observed at the Johns Hopkins Hospital during the last eighteen years. Usually the symptoms are present at birth, but may first appear after operation for removal of an external sac. In a few instances the symptoms come on without warning at any time during childhood; this is generally explained as a result of growth of the spinal column, with consequent traction upon nerve roots caught in the sac. The differential diagnosis from sacral poliomyelitis is difficult in such cases. In lesions of the spinal cord



associated with breech extraction, bladder function is almost invariably disturbed to some degree.

**Diagnosis.**—Acute retention of urine from detrusor paralysis or sphincter spasm is likely to be mistaken for the purely functional disturbance so common in acute illnesses of all kinds. When neurological bladder of the sphincterospastic type is suspected, particularly at its initial appearance, catheterization should be avoided if possible in the hope of avoiding infection of the urinary tract and with the expectation of spontaneous improvement in the condition. Late cases with dilatation of the upper urinary passages and perhaps with an infected urine call for complete urological investigation. Cystography usually demonstrates ureterovesical backflow with more or less dilatation of the ureters and renal pelves. With cystoscopy the atonic neurological bladder often presents a characteristic appearance. After the institution of drainage, it fails to regain its tone, in contrast to the primarily obstructive type.

Weakness of the vesical sphincter must be distinguished from functional enuresis due to habit or poor training. If there is continuous dribbling at any time of day and a small bladder, an organic condition may be assumed. When enuresis is intermittent, the diagnosis is more difficult. Variability of the symptoms suggests a functional condition. The presence of a relaxed anal sphincter is highly suggestive; observation of the relaxed vesical sphincter with an endoscope is conclusive.

**Treatment.**—This is usually unsatisfactory. The patient with detrusor weakness may be trained to some extent to control the automatic voiding with his abdominal muscles. When there is a large element of sphincter spasm, great relief and even cure may follow resection of the bladder neck. In a girl of eight years described by Campbell, this procedure reduced the residual urine from 300 to 2 c.c.; and in another case from 180 to less than 20 c.c. When the sphincter is not completely paralyzed, restriction of fluids and training may accomplish something. With continuous dribbling mechanical appliances to control the urine are indicated. Plastic operations, such as construction of a new sphincter from the gracilis muscle, have been carried out successfully in a few cases.

The chief importance of the neurological bladder in childhood lies in knowing when not to diagnose it. It has become a common practice to x-ray the spine in cases of enuresis; too often the discovery of a spina bifida occulta leads to the hasty conclusion that this is responsible for the symptoms, and treatment is abandoned as hopeless. It should be appreciated that spina bifida occulta is a relatively common condition and by no means invariably accompanied by bladder disturbance. We have records of 23 patients seen in the Harriet Lane Home in whom enuresis was associated with this lesion. In 4 there was definite evidence of neurological bladder; in 2 others some doubt existed about the nature of the bladder condition; in the remaining 17 patients enuresis was apparently functional and responded to treatment quite as well as in cases without spina bifida.

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## CHAPTER LXXXIII

### URINARY CALCULI

Small renal calculi are fairly common in infancy. In the autopsy room one frequently sees, on opening the kidneys of young infants, fine brown granules in the pelvis and calices, and occasionally a calculus as large as a pea is found. Stones of this type are usually composed of uric acid. They are often bilateral. After infancy they tend to disappear, being either dissolved or passed *per urethram*.

Large calculi—either in the kidney or bladder—are exceedingly common in certain countries, notably in Hungary, Russia, Asia Minor and India. Bókay in Budapest reported 1836 cases in young children, the great majority of which were vesical calculi. In the United States large calculi are uncommon. The published reports indicate that the location and composition of these stones is similar to that in countries where the condition is common. About two-thirds of the calculi are vesical. Uric acid and urate stones are by far the most common, the next largest group being calcium phosphate stones. Urolithiasis is somewhat more frequent in boys. Large stones have been encountered even during the first year of life.

Little is known as to the cause of urinary lithiasis. The small stones seen in the kidneys of infants are doubtless related to the high excretion of uric acid at this time of life. The explanation of the large stones is obscure; it is likely that some damage to the mucosa of the urinary tract is a prerequisite for their formation. Racial factors do not account for the marked geographical differences seen; urolithiasis is common enough in Russia, but is almost unknown among the Slavic population of Czechoslovakia.

*Renal Calculi.*—The small deposits in the kidneys give no symptoms, nor do they cause renal damage. Larger stones may cause pressure necrosis and progressive loss of renal function. Some local reaction at the site of lodgment is practically always present, causing pyuria, but aside from this, such stones may be “silent.” We once saw a child of three years with a calculus completely filling the kidney pelvis, which produced no symptoms except a moderate pyuria for more than a year, when it was removed. In the majority of instances a renal stone declares itself by causing partial or complete obstruction of the renal pelvis or the upper part of the ureter. The symptoms may be anything from vague pains to the most severe colic. Renal colic is often caused by passage of a stone into the ureter. In a typical case there are sudden attacks of severe sickening pain in the kidney region, radiating down the thigh and sometimes to the external genitalia. Tenderness and muscle spasm may be present. Often there is nausea and vomiting; prostration may be marked; in some cases there is fever. When the obstruction is complete there may be reflex anuria, no urine being passed even from the normal side; but more often the urine is passed frequently in small quantities; in most



instances hematuria occurs; urinary gravel may be passed. The duration of the symptoms is indefinite. They may terminate abruptly with passage of the stone into the bladder, or they may persist in acute or subacute form. Impaction of the calculus in the ureter may cause dilatation of the ureter above the obstruction, hydronephrosis and ultimately pyonephrosis. In other instances the shape of the stone is such that comparatively little obstruction is produced; the inflammatory reaction in the ureteral wall at the site of lodgment may, however, result in ulceration and the formation of a cicatricial stricture.

Bladder symptoms are by no means uncommon with renal calculi; they result from the infection of the urine or from reflex stimuli. There may be frequency, dysuria or incontinence; there may be genital irritation. In some cases digestive symptoms dominate the picture—failing nutrition with perhaps nausea and vomiting.

*Vesical Calculi.*—These may originate in the bladder or may represent the growth of renal stones which have passed down the ureter. Sometimes a history of preceding renal colic can be obtained. Bladder stones may be silent, but often enough they give rise to cystitis, and there is frequency, urgency and incontinence of urine. The urine may show blood, and mucus or pus may be present. An alkaline urine with *B. proteus* infection is found in many cases of stone. As a rule, however, infection of the urine is less constant and less marked than in the case of renal calculi. If the stone becomes impacted at the entrance of the urethra during micturition, very characteristic symptoms develop. There is sudden pain, usually in the middle or toward the end of urination, which may cause the child to seize the external genitalia; there may be stoppage of the stream and severe straining. The ability to void only in peculiar positions is rarely met with in children. The straining often leads to rectal tenesmus and even to prolapse. This complication is so frequent that in a case of persistent prolapse, stone should always be suspected. The genital irritation may lead to the habit of masturbation. Incontinence of urine is often the principal symptom; in many cases it occurs only during the day.

Vesical and renal calculi not infrequently become impacted in the urethra; this may cause complete or almost complete stoppage with retention of urine; there may be urethral hemorrhage.

**Diagnosis.**—The existence of a urinary calculus can be suspected from the symptoms mentioned above. Renal colic may be confused with any of the numerous causes of acute abdominal pain; in infants it is most often mistaken for intestinal colic. Not every case of ureteral colic should be regarded as due to stone, however. A temporary ureteral obstruction may result from masses of crystals caught in the ureter; sometimes eating rhubarb and other vegetables high in oxalate content will cause the formation of oxalate crystals in profusion with symptoms of colic. Ureteral stricture is not necessarily due to causes originating in the urinary tract; it may result from appendiceal adhesions.

A certain number of kidney stones can be seen in an ordinary x-ray plate. Pyelography and catheterization of the ureters with waxed tip bougies have added greatly to the number of renal calculi correctly diagnosed.

Stones in the bladder can sometimes be felt by bimanual palpation with one



finger in the rectum and the other hand over the pubes; the method is not very trustworthy. Cystograms or exploration of the bladder with a metal searcher will enable one to diagnose a stone with certainty. In every case of urinary calculus it is desirable to make a careful study of the function of both kidneys.

**Treatment.**—The medical treatment of urolithiasis is not satisfactory. Instances have been reported in which diuresis and the maintenance of a highly acid urine have caused phosphate and oxalate calculi to crumble and be discharged, but these successes are rare. At the most such an attempt should be continued not longer than a week or two. To postpone the removal of calculi may result in increased kidney damage. The procedures used with calculi of different types and locations are matters for the urologist or surgeon to decide. They are discussed in special works on urology.

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## CHAPTER LXXXIV

### MALFORMATIONS OF THE GENITO-URINARY TRACT

These are by no means uncommon. They are found in 5 to 8 per cent of autopsies in infants, and somewhat less frequently in older subjects, since the malformations themselves are often predisposing causes of death.

### MALFORMATIONS OF THE KIDNEY AND URETER

These occur in from 2 to 3 per cent of all autopsies on infants. The frequency of the different lesions is well illustrated by the following table taken from Bugbee and Wollstein's report of 4903 autopsies:

<i>Malformation</i>	<i>Cases</i>
Rudimentary or absent kidney.....	6
Double kidney .....	3
Supernumerary ureter .....	1
Fused kidney (horseshoe 9; sigmoid 1).....	10
Ectopic kidney .....	5
Movable kidney .....	1
Cystic kidney .....	20
Hydronephrosis (single 19; double 25).....	44
Pyonephrosis (single 3; double 6).....	9
TOTAL .....	<hr/> 99

Seventy per cent of these malformations were in males; the left kidney was affected twice as frequently as the right.

Some of these malformations are of little clinical interest and produce no symptoms throughout life. With almost any type, however, the susceptibility of the kidney to stone formation, to infection, or to degenerative diseases seems to be increased. Two groups only are by themselves of clinical importance—congenital cystic kidneys and malformations causing urinary obstruction.

**Congenital Cystic Kidneys.**—The cause of this condition is obscure. The cysts are unquestionably formed by dilatation of the uriniferous tubules, but whether this results from obstruction or from a defect in the wall of the tubule at the point where the collecting tubule unites with the mesonephrogenic anlage is not settled. The occurrence of an occasional small cyst in the kidney is relatively common and of no significance. The term congenital cystic kidney is reserved for those cases in which the process is exaggerated or widespread. The disease is often familial; both kidneys are usually affected. Two types are met with; in one the cysts are few in number and large. Symptoms of tumor are in the foreground. In extreme cases the mass may interfere with the birth of the child or may cause digestive symptoms by pressure on the gastro-intestinal tract. Large tumors may develop at any time during life from the sudden growth of small cysts.



In the more common type of cystic kidney the cysts are small and numerous. The kidney may be studded with them and yet be normal in size. In extreme cases the organ consists of a mass of cysts bound together with connective tissue in which but a few functional units remain. The symptoms in this type are due to chronic renal insufficiency—there is hypertension, a urine with fixed specific gravity, and eventually nitrogen retention and death in uremia. In the severest cases this develops at an early age; in others the functioning parenchyma is sufficient for the needs of early life, evidence of renal insufficiency appearing only after years with the gradual growth of the cysts or with the increased demands on renal function coincident with the growth of the individual. Cases of long standing renal insufficiency may lead to dwarfism (renal dwarfism) and changes in the bones resembling rickets (renal rickets).

Both types of cystic kidney may be combined in the same individual and the symptoms of tumor and insufficiency may coexist. In other cases the picture is complicated by infection or by a superimposed nephritis, which may cause the underlying malformation to be overlooked.

The possibility of cystic kidneys should be considered in all cases of progressive renal insufficiency in childhood. In many instances the diagnosis can be definitely established by a pyelogram. The so-called "spider pelvis"—an elongated pelvis with flattened minor calices and elongated major calices is characteristic. The disease is not amenable to treatment.

**Urinary Obstruction—Hydronephrosis.**—This may occur from a great variety of causes—from a calculus anywhere in the urinary tract, from a neoplasm, usually of the kidney, from inflammatory strictures of the ureter or urethra or from lesions of the nervous system affecting the emptying mechanism of the bladder. The great majority of instances, however, are due to malformations. Malformations of the kidney—fused kidney, double kidney, or ectopic kidney—in some instances give rise to obstruction and hydronephrosis. Obstruction of the ureter may result from congenital strictures or valves, from the pressure caused by aberrant blood vessels or from kinking in the case of a movable kidney. Congenital obstructions of the urethra are found almost exclusively in boys. The commonest ones are valves extending from the verumontanum to the wall of the urethra; other causes of obstruction are congenital hypertrophy of the verumontanum and diaphragms obstructing the urethra at any point. In some instances it is not possible to demonstrate an obstruction of the lower urinary tract, although there is progressive dilatation of the ureters and hydronephrosis. Such cases are attributed to defective innervation of the bladder or to faulty functioning of the ureterovesical outlet; they are found in both sexes.

The clinical picture in cases of urinary obstruction depends upon whether this is supravescical or infravescical, and, in the former case, whether it is bilateral or unilateral. Supravescical obstructions usually progress rapidly, since the bladder is unable to protect the ureter and kidney from back-pressure. There is progressive loss of renal function and dilatation of the urinary passages above the lesion. Extreme hydronephrosis rarely develops with bilateral supravescical obstructions, since the patient usually succumbs before this can take place. When the condition is unilateral the symptoms of failing renal function are not seen, for the opposite



kidney undergoes compensatory hypertrophy; phthalein and urea excretion tests give normal figures. The tumor is usually the first symptom to attract attention, though there may be vague pains in the loin, radiating downward, as in any case of hydronephrosis. The urine may become infected, but not with the regularity which is seen in the case of obstructions below the bladder.

With infravesical obstructions the bladder undergoes hypertrophy, its walls become trabeculated, and for a time it may compensate entirely for obstruction. This compensation may continue for years if the obstruction is not very marked, and no symptoms may be noted. In more severe cases, the compensation breaks after a longer or shorter time; the bladder does not empty completely and begins to dilate. Back pressure is then transmitted to the ureters and kidneys and there follows progressive impairment of renal function, followed by bilateral hydro-ureter and hydronephrosis. The bladder wall sometimes stretches irregularly, giving rise to an organ of bizarre shape, or to diverticula. Sometimes the bladder function fails completely and there is extreme distention with overflow incontinence and continuous dribbling. Infection may occur at any time; it develops in the great majority of cases after the bladder has become decompensated.

The symptoms of infravesical obstruction are usually characteristic. There may be a history of difficult urination and dribbling from birth; with each attempt to pass urine only a small amount is expelled after much straining. When the obstruction is less marked, symptoms may be wanting for years. Evidences of uremia may be the first to attract attention, but on careful questioning a history of difficulty in urination is obtained—hesitation during urination, difficulty in initiating the act, straining, or periods of acute retention. The onset may be with symptoms of cystitis. Examination of the abdomen shows a firm globular or irregular mass in the hypogastrium which remains even after urination; rectal examination may help in identifying this as a distended, hypertrophied bladder. Leading up from this into each flank, irregular masses—globular or elongated—can sometimes be felt; these are the dilated, tortuous ureters. The renal tumors are often palpable, but less constantly than the hypertrophied bladder. Hydronephrosis gives a movable, fluctuant tumor; this may serve to distinguish it from cystic kidney or renal neoplasm. Attacks of dull pain in the flank are common.

Whenever an obstructive lesion is suspected, special studies of the urinary tract are indicated. An ordinary x-ray may show the outline of an enlarged kidney or a calculus which is causing obstruction. Cystography will usually demonstrate obstructions below the bladder, showing reflux into the dilated ureters. Should this fail to reveal a lesion, intravenous pyelography may be attempted. Cystoscopy and ureteral catheterization may be required to determine the function and the presence of infection in the two kidneys independently. Such information is essential in deciding the question of a nephrectomy. With a low urinary obstruction and dilated bladder, there is great danger of shock and complete, possibly fatal, anuria if the pressure is suddenly relieved; gradual decompression of the bladder must be employed. When urinary drainage is established, there is usually a rapid return of renal function during the succeeding week or two; operative procedures are best postponed until this has taken place. Many obstructions can be removed most satisfactorily, notably calculi, and congenital valves or dia-



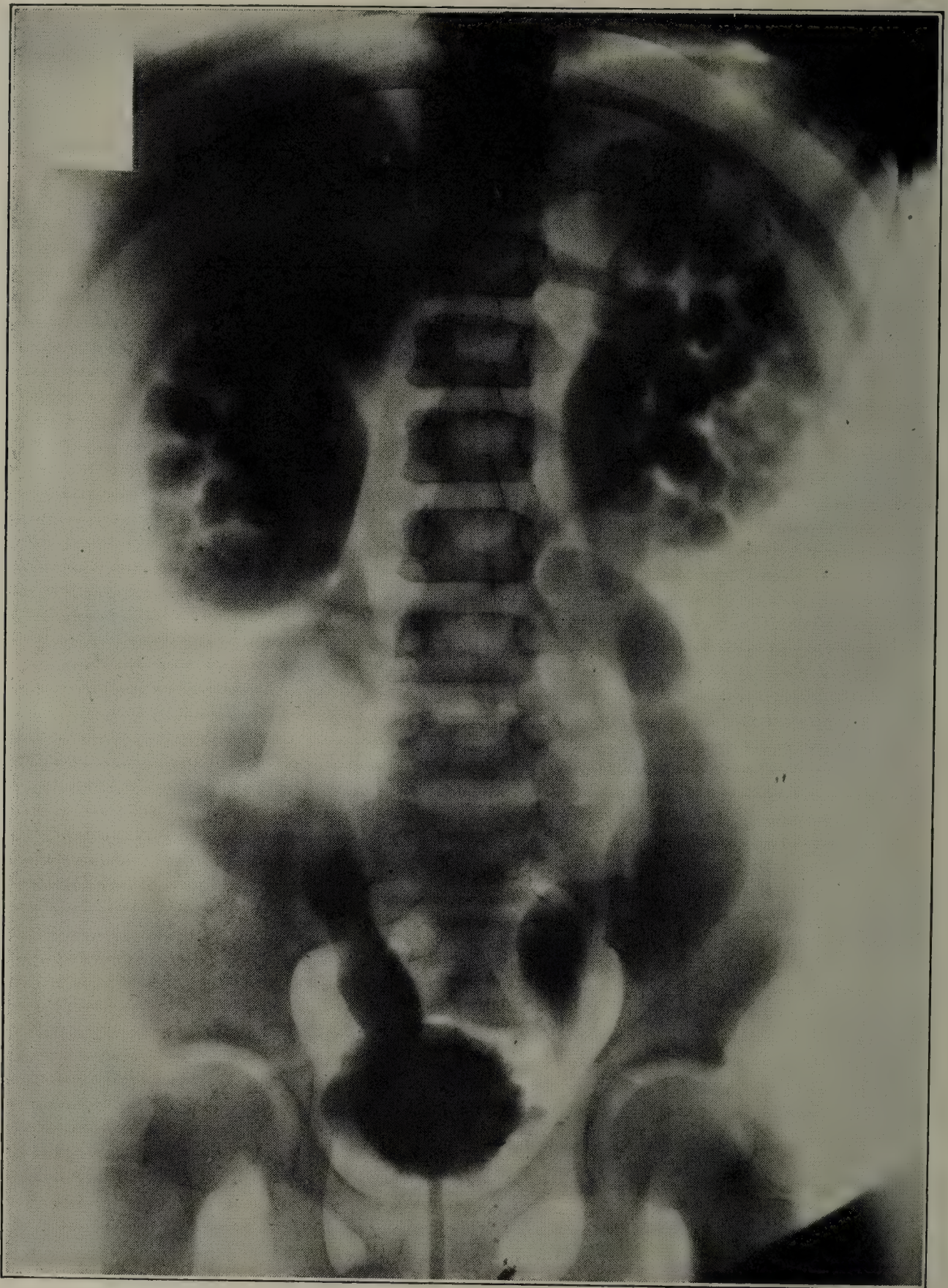


FIG. 110.—CYSTOGRAM IN A CASE OF CHRONIC PYURIA.

The bladder is contracted and shows irregularities and actual diverticula in its outline. Opaque material has flowed freely past the incompetent ureterovesical junctions and has filled the tortuous and dilated ureters and the dilated and deformed renal pelves and calices.

Norma G. (B.H. 231938) had scarlet fever at five years of age, after which she was always below par, underweight and easily tired. Obstinate enuresis; periodic attacks of abdominal pain. At ten years of age pyuria was found and she was sent to the hospital for examination. The basis of the condition appeared to be a congenital malformation of the spine, associated with a disturbance of bladder innervation. Urinary retention eventually resulted in dilatation and infection of the entire upper urinary tract. She died in uremia at twelve and one-half years of age.

phragms in the posterior urethra. The extent to which the urinary tract may recover—both functionally and anatomically—after the removal of an obstruction is often astonishing. Kidneys which have been almost functionless may exhibit



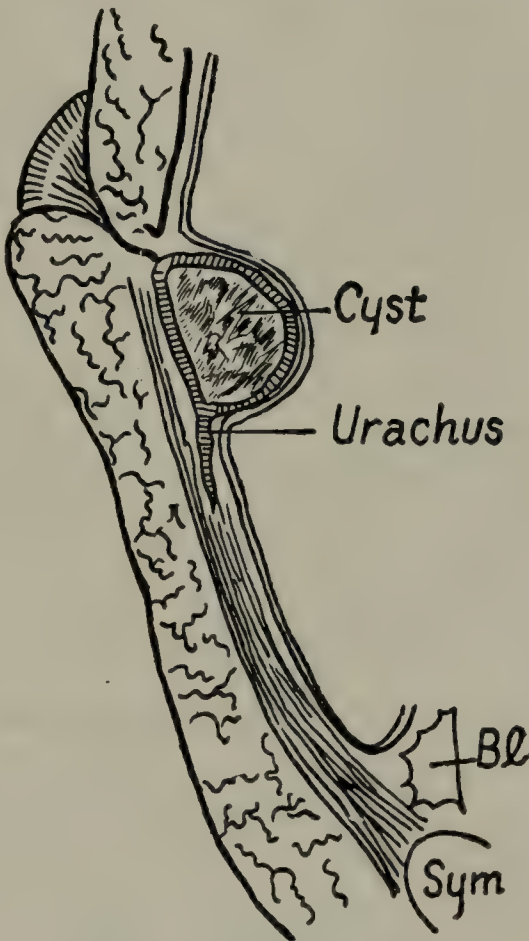
normal function within a few weeks; moderate degrees of hydro-ureter and hydro-nephrosis have been known to disappear entirely within six months. When there has been extensive destruction of the renal parenchyma, or when the most extreme types of ureteral dilatation and hydronephrosis are present, such recovery is of course impossible. In general, the degree of anatomical change is a more reliable prognostic indication than the renal function. The presence of marked infection is always unfavorable.

**Movable Kidney.**—This is a rare condition in young children. Comby has collected 18 cases, of which 16 were in girls and 2 in boys. Movable kidney was recognized before the tenth year in 8 cases, and in 2 of these before the fourth month. It has been ascribed to too long a pedicle, which may be congenital; also to pressure from abdominal tumors and to injury. The most important symptoms are paroxysmal pain which may follow exertion, and a movable tumor. This may be found, as in one of our cases, in the pelvis. A twist in the ureter may produce hydronephrosis.

MALFORMATIONS OF THE BLADDER

Most of these are exceedingly rare. Reduplication of the bladder and many types of congenital diverticula are described. Only two malformations are of clinical importance, those in which the urachus or a portion of it persists and exstrophy of the bladder.

**Patent Urachus and Urachus Cysts.**—Patency of the urachus with discharge of urine from the umbilicus is a rare malformation. It is usually associated with complete obstruction of the urinary tract below the bladder. Persistence of a portion of the urachus is not so very uncommon, however. There may be a blind passage opening at the umbilicus, or an internal blind portion connected with the bladder. By far the most common variety is that illustrated in the diagram in which a totally blind cyst remains. The frequency of different forms of persistent urachus is given by Weiser, who collected 70 cases, as follows:



Completely patent urachus .....	9
Blind external .....	7
Blind internal .....	8
Totally blind .....	46

A urachus cyst may be found at any point along the course of the urachus, most frequently near the umbilicus. We have seen several such instances. Not infrequently the cyst becomes infected and there is a history of recurring attacks of pain and tenderness; a localized mass may be palpated. Occasionally the resulting abscess ruptures—inwards or outwards. Urachus cysts should be removed if they give symptoms, preferably between acute attacks.

FIG. 111.—CYST OF THE UPPER END OF THE URACHUS (AFTER DAVIS).



**Exstrophy of the Bladder.**—This may occur in either sex, but the great majority of cases are in boys. In the complete form, in boys, there is a median fissure extending from the umbilicus to the tip of the penis; it includes the anterior abdominal wall, the pelvic bones and the urethra. The bones are entirely separated at the symphysis, or are connected by a fibrous band. The hypogastric region is occupied by a red, mucous surface, slightly corrugated, which is all that remains of the bladder. In the lower lateral portions of this the ureteral orifices are seen as slightly rounded elevations from which urine oozes. The verumontanum and the orifices of the ejaculatory ducts are visible in the exposed prostatic urethra. The penis is short and spade-like, it presents a shallow furrow on the dorsal surface, or, in some instances, a deep cleft. The testes are often in the abdominal cavity.

In girls the deformity is quite analogous. There is a division of the clitoris and separation of the labia. The fissure may be so deep as to extend nearly to the anus. The vagina is usually absent or rudimentary. In some instances the rectum opens into the bladder cavity.

Because of the continuous leakage of urine it is almost impossible to keep the clothing dry; these patients are usually accompanied by a strong ammoniacal, urinous odor; they are a nuisance to themselves and to all about them. They often walk with a curious waddling gait. The surrounding skin may become excoriated. In some instances ulceration of the exposed bladder occurs; malignant change is a rare complication. It is surprising, however, how few of these patients develop ascending urinary infection. The condition is quite compatible with long life.

Operation for the relief of exstrophy should always be undertaken. If the exstrophy is only partial, the operation of choice is probably a plastic reconstruction of the anterior wall of the urogenital tract. This has been done successfully even in complete cases, and has obvious advantages from the reproductive point of view. On the whole, the most satisfactory results have been obtained by transplantation of the ureters into the rectum. One ureter is transplanted at a time; the remnant of exposed bladder is resected. In successful cases the rectum soon becomes tolerant of the urine, holding it for hours without difficulty. The mortality from ascending urinary infection following the operation is fairly high, though some clinics have held it below 10 per cent. The risk, however, is justified in view of the tedium of the untreated deformity.

## MALFORMATIONS OF THE MALE GENITAL ORGANS

**Epispadias.**—In this condition the urethra opens on the dorsal surface of the penis. There may be simply a division of the glans, or the fissure may extend the whole length of the organ. It may be complicated by exstrophy of the bladder.

**Hypospadias.**—Here the urethra is not continued to the end of the penis, but opens on the inferior surface some distance back, being represented in front of this only by a shallow furrow. There is usually some degree of congenital chordee present. In more severe forms there is a deep fissure dividing the scrotum or even the perineum, into which the urethra opens. This latter condition is likely to be mistaken for hermaphroditism, especially as the testicles are frequently undescended. Hypospadias is a more common malformation than epispadias. Plastic operations for the relief of these conditions are described in works on urology.



**Accessory Urethral Canals—Para-urethral Ducts.**—A great variety of these are described. Accessory urethral canals may open at any point on the dorsal or ventral surface of the penis. Multiple openings are sometimes present. The duct may communicate with the main urethral channel and discharge urine, or it may be blind. Diverticula of the urethra are also described which have no external communication.

**Congenital Obstructions of the Urethra.**—These have already been referred to. In rare instances, considerable portions of the urethra may be completely obliterated; a patent urachus is then usually present. Partial obstructions are by no means uncommon. There may be a diaphragm across the urethra at any point, through which a small opening persists. The most frequent type of obstruction consists of valve-like leaflets passing from the verumontanum to the urethral wall. These may offer no resistance to an instrument introduced from below, but catheterization from above is next to impossible. More than twenty cases of this type which have been observed on the pediatric and urological services of the Johns Hopkins Hospital were recently reported by Young and McKay. Several instances of posterior urethral obstruction due to congenital hypertrophy of the verumontanum were reported by Bugbee and Wollstein.

**Phimosis.**—This is a narrowing of the preputial orifice. The degree of phimosis varies greatly. In very rare cases there is no preputial opening. In other cases the orifice is so small that no part of the glans can be exposed. This may cause obstruction to the flow of urine, and straining during micturition. The presence of residual urine in the preputial cavity often leads to infection and balanitis; it may be complicated by urethritis and cystitis. The list of reflex phenomena that have been ascribed to phimosis is a long one. However, it is very doubtful that phimosis is an important factor in the neuroses of infancy and childhood. The general experience with circumcision as a cure for such conditions has been very unsatisfactory. The irritation from an infected prepuce or balanitis may lead to priapism and encourage masturbation. It may increase the reflex irritability of the bladder and play a part in the production of enuresis. A redundant prepuce is often associated with phimosis, but in many cases of redundant prepuce no phimosis exists.

Phimosis should receive attention in infancy. When the prepuce is long, circumcision should be performed, even when the degree of phimosis is slight. Many cases of phimosis in which the prepuce is not long can be relieved by stretching. If no part of the glans can be exposed, however, circumcision is indicated.

**Paraphimosis.**—In this condition there has been a failure to draw the prepuce forward after retraction, so that it constricts the penis just above the corona, causing edema of the glans and of the distal portion of the prepuce. The longer it remains in this position, the greater the edema and the more difficult the reduction. In neglected cases ulceration of the swollen parts occurs.

If it is of only a few hours' duration, paraphimosis can usually be reduced without much difficulty. Steady pressure should be applied to the glans for two or three minutes to reduce its size before attempting to slip the prepuce forward over the corona. Considerable force may be required. If the maneuver



is successful, the edema of the prepuce will usually subside within twenty-four hours. In obstinate cases a dorsal slit may have to be made, but owing to the distortion produced by edema, the surgery of paraphimosis is not simple and should not be undertaken without experience. In any case, after recovery from the acute situation, the patient should be circumcised.

**Adherent Prepuce.**—This is so constantly present that it can hardly be regarded as a malformation. It is, however, a condition often needing attention in male infants. The prepuce should be retracted so as to expose the glans completely. The smegma should then be washed away, the glans covered with a drop of oil, and the skin drawn forward. This should be repeated daily until there is no disposition to a recurrence of the adhesions.

**Undescended Testicle—Cryptorchidism.**—In fetal life the testes are situated in the abdominal cavity below the kidneys. They usually descend into the scrotum during the ninth month, but in children born at term the testicles may be in the inguinal canal, or even in the abdomen. The former condition is quite frequent, being present in fully 10 per cent of all male children. In most of these the descent takes place without difficulty during the first weeks of life, and causes no symptoms. In others the condition may persist. Spontaneous descent may take place at any time before puberty, the chances, however, steadily lessening as age advances. When in the inguinal canal, on account of its exposed situation, the testicle may be injured, or become painful and tender as puberty approaches. In any abnormal position it probably will not develop properly, and may remain without function; but interference with the development of the body is rare. Hernia is a frequent complication.

In most cases the administration of anterior pituitary-like hormone from pregnancy urine will cause descent of the testis in from three to six weeks. Twenty-five rat units are given daily by subcutaneous injection, the dose being increased in the course of ten days to 250 units a day, where it is maintained. If there is no improvement within six weeks the attempt should be abandoned. In refractory cases when the cryptorchidism is such that the testes cannot be pressed into the scrotum operation should be performed, preferably between the ninth and eleventh years.

**Hydrocele.**—This is an effusion into some part of the peritoneal pouch brought down by the testicle in its descent. The condition is very common in newly born infants; it may appear shortly after birth. Usually it disappears spontaneously; few cases are seen after the second year. Several varieties are met with. The tunica vaginalis may communicate with the peritoneal cavity and the hydrocele extend the entire length of the cord; there may be a pouch of peritoneum which follows the cord downward for a distance, ending blindly. The anatomy of these types is essentially the same as in congenital hernia, but the opening is too small to permit prolapse of the intestine. In other cases the effusion is confined to the tunica vaginalis, to the tunica and lower part of the cord, or it may consist of a blind cyst located somewhere in the course of the cord. The distinctions between these varieties are largely matters of academic interest. It is of importance, however, to distinguish hydrocele from hernia. When the hydrocele does not communicate with the abdominal cavity, the tumor is felt as an elastic, nonreducible mass which transilluminates readily. It does not vary



in size over a short interval, as between night and morning, and it tends to retain its shape. When there is communication with the peritoneal cavity, the tumor is reducible, but, unlike a hernia, it is reduced slowly and evenly; it does not go back *en masse* like a hernia, nor is there gurgling. The percussion note may be of assistance, but it is rare for hernias at this age to be tympanitic unless they are so large that the diagnosis is obvious. Hernia and hydrocele may exist on the same side.

Operative measures are seldom called for in any variety of hydrocele seen in infancy; it usually disappears spontaneously within a few months.

**Hermaphroditism.**—True hermaphroditism, in which the individual contains gonads of each sex, is an exceedingly rare condition. An interesting case of this kind was recently observed by Young. False hermaphroditism—a condition in which the gonads belong to one sex exclusively, but the characteristics of the external genitalia make the determination of the sex difficult—is not especially rare. It may occur in either sex. Plastic operations upon the genito-urinary tract should be permitted only after the true sex has been determined; this latter may require laparotomy.

## MALFORMATIONS OF THE FEMALE GENITAL ORGANS

Exstrophy of the bladder has already been described. Various degrees of incomplete epispadias may be encountered in females. Obstructive lesions of the urethra are almost unknown. *Adhesions about the clitoris* are not very uncommon, and have been regarded as a possible cause of masturbation. They may be broken up under anesthesia, but it is unusual for this to cause any great improvement in that habit.

*Atresia of the vulva* is not uncommon. It is usually due to delicate adhesions between the labia. As a rule the condition is not complete, a small opening permitting the urine to escape. These adhesions can be broken apart quite readily by separation of the labia; very little force is required, and an anesthetic is not necessary. If they are allowed to persist, dense adhesions may form.

An *imperforate hymen* is sometimes seen, the vagina being closed by a thin, almost translucent membrane. If discovered in infancy this should be opened by a small incision; this will prevent accumulation of the mucoid secretions, and, later, of menstrual flow.

With the exceptions already mentioned, deformities of the female genitals belong to the domain of gynecology rather than to pediatrics, since they are chiefly of the internal organs, and do not ordinarily give symptoms before puberty.

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## CHAPTER LXXXV

### INFECTIONS OF THE GENITO-URINARY TRACT

#### PERINEPHRITIS—PERINEPHRIC ABSCESS

This is an inflammation of the cellular tissue surrounding the kidney, which may terminate in resolution or suppuration. It may develop from the extension of a renal inflammation, or as a metastatic infection from some distant focus. In other instances the disease is apparently primary; such cases often follow trauma or exposure to cold; they may appear without assignable cause. Perinephritis may occur at any age; we have seen it fully developed in a child of six months, with symptoms dating back to four months of age. Townsend observed a case in an infant five weeks old.

The onset may be abrupt with chill, high fever, prostration and localized pain; or it may be insidious with few constitutional symptoms, but with progressive lameness, referred to the hip or spine. As the disease progresses fever is a constant symptom; there is increasing deformity, with flexion of the thigh and deviation of the spine. Passive extension causes pain and is resisted, although other movements of the hip are not affected. Pain is usually felt in the loin, but frequently it is referred to the groin, thigh or knee. Local tenderness over the kidney posteriorly can usually be detected.

The duration of the disease is indefinite. After two or three weeks the symptoms may gradually subside; on the other hand it may persist in subacute form for months. Suppuration occurs in about two-thirds of the cases. The abscess may point posteriorly in the iliocostal space, or may burrow forward between the abdominal muscles and point above Poupart's ligament; a typical psoas abscess may develop; in other instances, it may rupture into the peritoneal cavity or the urinary tract, or may perforate the diaphragm. Sometimes the abscess reaches an enormous size before finding an outlet.

The disease is most often confused with tuberculosis of the hip or early caries of the spine. These conditions develop more insidiously, however, and are more chronic; the x-ray and tuberculin reaction are of assistance in ruling them out. When perinephritis follows trauma, persistence of symptoms for a week or two should make one suspicious, even if constitutional symptoms are not marked. We have known cases to be mistaken for appendicitis.

A careful examination in cases of perinephritis will usually disclose the perirenal location of tenderness. Local edema in the region of the affected kidney is a valuable point in favor of perinephric abscess. The diagnosis has sometimes been established by exploratory puncture in the costovertebral angle.

Treatment consists in bed care and keeping the patient as quiet as possible throughout the attack. Applications of heat or cold may be used in the early stage.



The drainage of perinephric abscess is a surgical problem. Recovery is usually rapid after such an abscess is properly drained. The prognosis in perinephritis depends upon associated conditions. In the presence of pyonephrosis, or when the condition is a manifestation of pyemia, the outcome is not particularly favorable. Nearly all of the primary cases, however, recover uneventfully.

### INFECTIONS OF THE UPPER URINARY TRACT (CYSTITIS; PYELITIS; PYELONEPHRITIS; PYONEPHROSIS)

Inflammations of the upper urinary passages are exceedingly common in early life; it has been estimated that they constitute about 1 per cent of all pediatric cases. A small proportion of these result from urinary stasis; in the remainder no abnormality of the urinary tract can be held responsible.

**Etiology.**—If one excepts those cases due to stasis, the great majority of these infections (75 to 90 per cent) occur in girls. The colon bacillus is the usual offending organism, although occasionally pyogenic cocci or other organisms or perhaps mixed infections are met with. Urinary infections sometimes occur in the newly born; on the whole, however, they are infrequent until after the third or fourth month. From then on until the age of two they are common, after which the incidence again decreases. There has been much argument as to whether these infections are blood-borne or ascend by way of the urine; the question is still an open one. The colon bacillus etiology, the fact that the condition is seen chiefly in the "diaper age," the sex incidence and the infrequency with which positive blood cultures are obtainable—all point to ascending infection. It is no longer necessary to postulate ascent by way of the lymphatics, for it is known that reflux flow of urine from the bladder up the ureter may occur in normal individuals. There are instances, however, in which such an explanation seems improbable—cases due to organisms other than the colon bacillus, and those in which a bacteriemia is present, the identical organism being found in the urine. Helmholz has induced infections by both routes in experimental animals.

Urinary infections may be primary or secondary. In older children they are seldom associated with other diseases. Primary infections are common enough in infants, but in these young subjects they are frequently associated with other pathological conditions—gastro-intestinal disorders in the summer and respiratory infections in the winter. It has been shown by Schwartz and by Helmholz, who studied catheterized specimens of urine in infants with gastro-intestinal disorders, that in 25 to 30 per cent of these cases the colon bacillus can be obtained by culture, although no further evidence of infection may develop. Whether the urinary infection is the result of diminished resistance, or whether it is due to a diminished flow of urine associated with fever, is not known.

The cases associated with abnormalities of the urinary tract are found in both sexes. Stasis may be caused by malformations of the upper or lower urinary tract, the latter being most common in boys; it may result from a neurological bladder, or from a urinary calculus. The bacteriology of this group on the whole shows nothing that serves to distinguish them. It is believed, however, that an alkaline urine associated with *B. proteus* infection is indicative of stone in the bladder.



Rarely, pus in the urine results from the direct extension of some pathological process outside the urinary tract. A paravertebral abscess from caries of the spine, a perirenal abscess or an appendix abscess may rupture into the urinary tract.

**Pathology.**—When the infection is due to some local cause in the upper urinary passages, such as a calculus or ureteral stricture, it is usually unilateral and is confined to the neighborhood of the lesion or parts above it. In other instances the process is diffuse. The amount of *cystitis* is variable. A cystitis sufficiently marked to give bladder symptoms is uncommon in infants, but more frequent in older children.

The chief lesion in these upper urinary infections is said to be a *pyelitis*: a catarrhal inflammation of the pelvis and calices with congestion and swelling of the mucous membrane, sometimes with minute hemorrhages. Pathological observations, however, are notoriously few. Nearly all the autopsies have been done either in cases of long-standing pyuria, or else acute cases associated with sepsis; in such instances it has been found that *pyelonephritis* is regularly present in addition to pyelitis; there may be merely collections of polymorphonuclear leukocytes or there may be small abscesses throughout the parenchyma of the kidney. The infection may die out and healing take place with scar formation. In a small proportion of cases, when there has been widespread destruction of parenchymatous tissue, the remaining renal tissue, though adequate for the immediate demands of the child, is not sufficient for his needs with subsequent growth. After a lapse of years symptoms of renal insufficiency appear. The clinical and pathological picture is discussed more fully under Chronic Nephritis. The term *pyonephrosis* is usually applied to an extreme condition in which the pelvis and calices of the kidney are greatly distended with pus, and in which compression has obliterated most of the renal parenchyma. This is rarely seen except with organic obstructions; it is the result of prolonged obstruction with infection. The mucous membrane of the pelvis is extensively altered. The remnants of parenchyma show marked evidences of infection.

**Symptoms.**—The term pyelitis is usually applied to this entire group of infections, with the implication that cystitis or pyelonephritis may coexist.

There are few diseases in which there is such variability in the severity of the symptoms. In perhaps the majority of instances pyelitis is so mild as to cause only a slight elevation of temperature for a few days. Symptoms are sometimes wanting altogether, the condition being discovered by a routine urine examination. In other instances the symptoms may be quite severe.

The onset may be insidious or may be abrupt with high fever, vomiting, chill, sudden pallor and perhaps marked nervous symptoms. Chills are common in older children, but infrequent under two years of age. The temperature is rarely sustained for more than a day or two; usually it shows wide swings, which often show an inverse relationship to the quantity of pus in the urine. Digestive symptoms may be conspicuous—anorexia, diarrhea or vomiting—sometimes there is marked dehydration. It may be difficult to decide whether these or the urinary symptoms are primary. Nervous symptoms are often marked at the outset, but seldom persist; there may be meningismus, convulsions or great prostration.



Sometimes the spinal fluid is examined for an explanation of these symptoms even before pyuria is discovered.

Abdominal tenderness and symptoms referable to the bladder are scarcely ever met with in infants; in older children they are more frequent. It is common for young infants to exhibit straining or writhing movements, associated with facial grimaces, which have been interpreted as due to the colicky pain accompanying the passage of masses of exudate through the ureter. The urine is diminished in quantity and highly acid, as in most febrile conditions. Ketone bodies may be present, especially in the first few days. The quantity of pus is most variable; pus may cause temporary obstruction of the ureter and be absent from the urine for a time. It is not an uncommon experience to meet with a fever which is sustained for several days, during which time urine examinations are negative for pus; suddenly, with a remission in the temperature a large quantity of pus is found in the urine. This may occur at the onset or during the course of the disease. The amount of pus may be only microscopic or it may constitute as much as 50 per cent of the volume of the urine. Clumps of pus cells are commonly found; they may be degenerated if there has been blockage for several days. Albumin is present in proportion to the amount of pus or the degree of nephritis; casts of all types occur when there is a true pyelonephritis. Red blood cells are of common occurrence; occasionally they are sufficient to produce gross hematuria. Epithelial cells from all parts of the urinary tract are usually present in great numbers. The infective organism—usually the colon bacillus—is easily obtained in pure culture from a catheterized specimen. Occasionally infection with a pyogenic coccus, especially the staphylococcus, precedes the colon bacillus infection.

Although pallor is often striking at the onset of the disease, anemia is uncommon except in cases of long standing. A leukocytosis of 15,000 to 30,000 is found in most acute cases. The patient's serum may agglutinate the colon bacillus in high dilution.

The duration of an acute attack is most variable. Constitutional symptoms are usually confined to the onset; rarely do they persist a week. Fever may last from a few days to weeks or even months. Microscopic pus can be found in the urine for some time after the fever has disappeared and sometimes the colon bacillus can be cultured for an even longer period.

Recurrences of the disease are very common. They may occur after weeks or months or even years. Such instances usually represent flare-ups of a latent infection. The disease may continue in a chronic state with occasional exacerbations. With these protracted infections involvement of the renal parenchyma is almost certainly present.

The following history may be cited to illustrate the main features of the disease in an uncomplicated case of moderate severity:

A previously healthy female infant of eight months was taken suddenly with a chill, followed by high fever. The illness continued for ten days before its nature was discovered. During this time the temperature ranged between 101° and 106° F., touching 105° nearly every day; the chill was not repeated. The other constitutional symptoms were not severe. The urine was found to contain macroscopic pus, which on standing was equal to one-twelfth of its volume. There were no signs of vulvitis or vaginitis, no



bladder symptoms, no localized tenderness, no vomiting or diarrhea. Epithelial cells of all kinds were found in the urine. Under no treatment except alkaline diuretics the temperature gradually fell to normal, and the pus diminished steadily in quantity. At the end of five weeks only an occasional pus cell was present. The child remained well.

In the newly born infant, pyelitis is a comparatively rare event, but should be kept in mind as a cause of obscure fever. It is equally common in both sexes and is probably of hematogenous origin. In most instances the course is benign. We have known of several instances in which vomiting was such a prominent feature as to suggest pyloric stenosis.

The cases seen in older children sometimes give more local symptoms. There may be bladder symptoms—frequency, straining, burning on urination and a constant desire to urinate. There may be pain or tenderness in the kidney region; muscular rigidity may be present. In some cases the pain is poorly localized and the condition may be confused with appendicitis.

Severe forms of pyelitis are seen at all ages, but a greater proportion of the cases in older children are severe. These occur in both sexes with equal frequency. Constitutional symptoms are very prominent; there is high fever, convulsions, or perhaps a typhoidal state with stupor and delirium. The course is protracted and the mortality relatively high. In these cases the kidney parenchyma is usually severely involved from the start. The urine contains casts as well as pus. Renal function tests, notably the phthalein test, indicate the extent of this involvement, and give valuable prognostic information.

A number of writers have called attention to the occurrence of jaundice in many of the severer cases of pyelitis; it is apparently due to focal necroses in the liver.

Those cases in which urinary infection is dependent on stasis follow a somewhat different course from the uncomplicated ones. They may commence abruptly, as other forms do, but they show little tendency to improve. The cause of the stasis may or may not give characteristic symptoms. In long-standing cases evidence of nephritis or renal insufficiency may develop. The tumor of a pyonephrosis may be the first symptom to attract attention.

In chronic pyurias which fail to respond to the usual methods of treatment, organic causes can be demonstrated in the great majority of instances if the patient is subjected to a urological study. A typical history of such a case is appended:

A girl baby, nine months old, had had repeated digestive upsets since birth. She had recently developed severe diarrhea with dehydration, fever and acidosis. The physical examination failed to reveal a localized infection, but the urine contained clumped pus cells and a trace of albumin. Under dietary restriction and administration of fluids all of the symptoms except the pyuria cleared up; this, however, persisted after several weeks of alkaline diuresis and other forms of medication. Renal function studies showed some impairment—the blood nonprotein nitrogen was 38 milligrams per 100 c.c.; the phthalein excretion was 45 per cent in two hours. On cystoscopy the bladder mucosa was found congested; the bladder urine gave a pure culture of *B. coli communis*. Strictures were demonstrated in both ureters 3 or 4 centimeters above the vesical orifice, the greatest obstruction being on the left side. The right ureter was not appreciably dilated; urine from this side was normal. The pyuria came entirely from the left ureter, which was considerably dilated above the stricture. The ureteral strictures were dilated at



intervals of a month at first, later two to four months apart. The renal function tests soon returned to normal. Pyuria and bacilluria gradually diminished in the course of a little over a year, except for two mild exacerbations, one of which was associated with pharyngitis and diarrhea. The distended ureter diminished in size during the course of the observations.

**Diagnosis.**—Although pyelitis may be suspected from the clinical symptoms, the diagnosis can only be made from an examination of the urine. This should never be omitted in cases of obscure fever; if pus is not found the examination should be repeated several times. The presence of a few white cells in the urine during a febrile attack does not warrant the diagnosis of pyelitis, particularly if there are no clumps. Even when the pyuria is unquestionable, one must make certain that the pus is actually coming from the urinary tract. In male infants a moderate pyuria and even occasional red cells in the urine may result from an infection of the prepuce or anterior urethra, or from local irritation caused by an ammoniacal diaper. In females, vaginitis is often the source of pus supposed to have come from the urinary tract. If pus is found in the urine, the external genitalia should be carefully inspected; in cases of doubt a catheterized specimen and urine culture should be obtained. In catheterization the first few drops of urine should always be discarded, since they are liable to be contaminated by organisms carried up from the urethra.

**Treatment.**—Patients who are febrile should be kept in bed. It is of the greatest importance to produce adequate diuresis. Water should be given freely by mouth, augmented by parenteral fluids if necessary. The use of alkali is sanctioned by custom. The usual procedure is to give sodium bicarbonate or sodium citrate in doses sufficient to make the urine alkaline. The quantity of bicarbonate needed to accomplish this is approximately 1 gram for each year of the child's age, given every four hours. The quantity of citrate is slightly in excess of this. Potassium citrate should not be used; instances of potassium poisoning have resulted when renal function is impaired. The alkali salts mentioned act as saline diuretics. It is doubtful if they exert any bactericidal action on the colon bacillus; this organism grows readily in the most alkaline urines.

A widely used remedy is hexamethylenamine (urotropin) which may be given in doses of 1 or 2 grains (65 to 130 milligrams) five or six times a day to an infant of one year, and in proportional doses to older children. It cannot be combined with alkali therapy, for it is effective only in an acid medium. Ammonium chloride or acid sodium phosphate is usually given simultaneously to insure an acid urine. Larger doses of urotropin may cause hematuria; Helmholz advises increasing the dose until this point is reached in order to obtain the maximum antiseptic action. A common practice is to alternate alkali therapy with acid and urotropin therapy every four or five days. Some patients seem to be benefited by this regimen.

Among remedies that have been enthusiastically advocated may be mentioned: hexylresorcinol, given by mouth; acriflavine, also given orally; mercurochrome and organic arsenical preparations given intravenously; autogenous vaccines and various forms of non-specific protein shock therapy. The multiplicity of remedies bears witness to the fact that no one of them is particularly satisfactory.

Quite recently Helmholz has reported astonishing improvement in chronic



infections of the urinary tract—even in cases of malformation—by means of ketogenic diets. On such a diet the urine, when it attained a pH of 5.6 or less, was found to be bactericidal to the colon bacillus, a property which Fuller has related to its content of betaoxybutyric acid. The diet may be commenced after the acute initial phase of the disease; it appears most effective when given for short 10-day periods, which may be repeated. A limited experience has impressed us with its efficacy.

The acute case will usually clear up within a few weeks if proper diuresis is maintained. It cannot be too strongly emphasized that persistent pyuria or frequently recurring pyuria is in itself presumptive evidence of urinary stasis and calls for a search for its cause. The history and physical examination may give evidence of some abnormality of the urinary tract or adjacent structures; in such a case a urological study may be undertaken at once. When there are no such special indications, medical treatment should at least be given a fair trial. The time required for this is, doubtless, somewhat arbitrary; we are accustomed to wait about four weeks before pursuing the investigation further by x-ray, intravenous pyelography and urological examinations. The more carefully such cases are studied the more frequently organic causes are disclosed. Campbell and Lyttle found obstruction and stasis in 95 per cent of cases of pyuria which had persisted more than one month. Some of these organic difficulties can be relieved.

For the case of chronic pyuria where no organic cause can be held responsible, lavage of the renal pelvis with silver nitrate has been recommended. Hunner believes that the successful results following this can be attributed to the concomitant ureteral dilatation. In such instances one should always make a careful search for foci of infection. A certain number of cases of this kind have been cured by tonsillectomy.

The question is sometimes raised as to whether these urinary infections in childhood bear any relation to pyelitis of pregnancy or to nephritis in adult life. Adequate data to answer this are not yet available.

## INFECTIONS OF THE MALE GENITALS AND LOWER URINARY PASSAGES

**Balanoposthitis.**—Inflammation of the glans and the mucous membrane lining the preputial cavity is one of the results of phimosis. It may follow injury or masturbation; the infection may start at the meatus from the irritation of the diaper. When the condition is marked the parts are red and painful, with considerable edema, and there is a purulent discharge. Abscess or even gangrene of the prepuce may follow. The fossa navicularis is commonly involved in these infections, but it is unusual for them to extend up the urethra for any distance. The condition is occasionally complicated by erysipelas. Diphtheria may develop there, as in any wound.

Under proper treatment the inflammation usually subsides within a few days. The object of treatment is proper cleansing and drainage of the preputial cavity. This is accomplished by frequent irrigations with saline or some mild antiseptic solution. If the edema is such that the foreskin cannot be retracted and the parts properly exposed and bathed, a dorsal slit operation is advisable. Circumcision should not be done during an attack.



**Urethritis in the Male.**—This may be nonspecific or gonorrheal. Both forms are far less common than in the female. Nonspecific urethritis complicating balanoposthitis has been mentioned above. The process is almost always confined to the anterior urethra. A chronic form of nonspecific urethritis is described in malnourished infants and children which does not bear any relation to preputial infections. This is certainly rare.

Gonococcus urethritis is more common. It may occur even in infants, but most of the cases are in those over seven years old. Unlike the disease in females, infection from clothing, towels and toilets does not seem to occur. In nearly all cases there can be obtained a history of direct sex contact or else of handling of the genitalia by an infected person. The symptoms are more severe than in the nonspecific urethritis; they resemble the adult disease. Local extension up the urethra is less frequently found than in adult infections, although cystitis, prostatitis and epididymitis are occasionally seen. Bubo in the groin is not infrequent. Conjunctivitis and arthritis are surprisingly rare. The diagnosis can nearly always be established by a stained smear of the pus; in case of doubt the organism should be cultured. Treatment differs in no way from that of the adult. Urethral stricture may develop in children following such an attack. Campbell has observed an impassable stricture of the bulbous urethra at twenty-two months in a boy who was infected at the age of eleven months.

Tuberculous infections of the genito-urinary tract are considered elsewhere.

### INFECTIONS OF THE FEMALE GENITALS AND LOWER URINARY TRACT

**Nonspecific Vaginitis.**—This term is applied to a group of infections affecting the vulva, the vagina and often the urethra as well; the bladder and internal genital tract are rarely involved. Nonspecific vaginitis may be seen at any age, even in infancy, but is most frequent after the second year. It occurs particularly in anemic or malnourished girls; it may follow any of the infectious diseases, particularly measles. Sometimes a local cause is directly responsible, such as pinworms, scabies, or a local lesion of varicella. It may follow trauma from attempted rape, or the introduction of foreign bodies. Neglect of personal cleanliness is often a predisposing factor. Masturbation may be the cause or the result of the condition.

The disease generally begins as a subacute catarrhal inflammation, the discharge being the first and often the only symptom. It is white or yellowish and rarely profuse; in some cases a foul odor is present. When the discharge is abundant, there may be excoriation of the labia and thighs. The mucous membrane is swollen and red. Microscopic examination of the discharge shows bacteria in large numbers and of many varieties, both gram-positive and gram-negative; pus cells are less numerous than in gonorrheal cases; there may be large numbers of epithelial cells.

With proper treatment the disease clears up quickly in children who are in good condition, seldom lasting more than two or three weeks. Under unfavorable conditions a leukorrheal discharge may last for a longer time. Treatment consists in frequent bathing and daily irrigations with warm saline or some bland antiseptic like boric acid. In persistent cases the irrigation should be followed by instillation



of a dropperful of 1 per cent mercurochrome or some astringent solution such as zinc sulphate and tannic acid (1 dram of each to 1 pint of water).

Uncleanly habits are not infrequently responsible for the failure of treatment or for recurrences. Children should be taught to use toilet paper in such a way that contaminated material from the rectum is not subsequently brought into contact with the vulva.

**Gonococcus Vaginitis.**—This disease is common in girls of all ages, even in young infants. Epidemics of it were formerly a veritable scourge in institutions for children; they still occur from time to time when precautions are not rigidly enforced. Day nurseries are a common agency for spreading the disease. Its prevalence in the child population at large varies greatly. Some years ago it was found that nearly 10 per cent of the female infants and young children applying for admission to the Babies' Hospital in New York were suffering from this infection; at the present time it is far less frequent. Although the disease is more common in that class of the population which attends dispensaries, cases in private practice are by no means rare.

Gonococcus vaginitis in children is not to be regarded as a venereal disease. An insignificantly small proportion of the cases are acquired by sex contact. In institutions the disease may be spread through faulty sterilization of diapers, clothing, bed linen, thermometers and other equipment, or by inattention to cleanliness of the hands of nurses. In schools and other public places it may be spread by toilet seats. Among companions, infection may result from manual contact, masturbation being frequent among infected individuals. Fully one-third of the cases seen in outpatient and private practice can be traced to an adult in the home. The young child may have slept in the same bed with an infected mother or sister; the infection may have occurred through baths, towels, clothing, toilets, etc.

The great susceptibility of the vaginal mucous membrane of the child to the gonococcus has never been adequately explained, nor is it known why these infections run such a benign course as contrasted with adult gonorrhea. It has been suggested that the gonococci concerned in these childhood infections are strains of low virulence, or organisms that have become attenuated, but this has never been established. It is more probable that the difference is due to the host rather than the organism.

*Symptoms.*—In the mild cases, the disease is limited to the mucous membrane of the vagina. There is a moderate creamy discharge, smears of which show pus cells and gonococci. There is very little redness of the mucous membrane and no local discomfort. In the more severe forms the discharge is copious, often thick and of a yellowish green color; it may be tinged with blood from slight erosions. It causes excoriation of the labia and inner surface of the thighs. Bladder symptoms—frequency and painful micturition—are usually present, indicating ascent of the infection up the urethra. Inspection of the genitals reveals a diffuse inflammation affecting the urethra, vagina, and hymen. The parts are intensely congested. With a speculum it can be seen that the infection extends up to the cervix; sometimes a purulent discharge is found coming from the cervix. Constitutional symptoms are rarely marked. Masturbation is not uncommon in these cases.



Involvement of the uterus, tubes and even the pelvic peritoneum may occur in children over five years of age, but is very rare; it is not seen in infants. Gonococcus sepsis or pyemia may occur. Arthritis is probably the most common complication; it is more fully discussed elsewhere. Conjunctivitis is surprisingly infrequent. Other complications occasionally observed are stomatitis, proctitis, pericarditis and endocarditis; instances of meningitis have been described. The upper urinary passages are ordinarily spared; it is very rare for organisms to ascend beyond the bladder.

*Diagnosis.*—An abundant purulent discharge is presumptive evidence of a gonococcus infection, but an exact diagnosis can be made only from a smear of the pus. Nonspecific cases usually show a great variety of bacteria of all kinds and many epithelial cells. In gonorrheal cases epithelial cells are not numerous and pus cells are abundant. Bacteria are few; gonococci are often the only organisms present and these may be hard to find. To be diagnostic they should be demonstrated within the pus cells, otherwise the smear is merely suggestive. A positive smear need not be corroborated by culture.

The technic of making smears is important. A small dry swab or platinum loop may be used and care should be taken to reach the secretions high in the vagina, not simply from the vulva. In doubtful cases direct smears should be taken from the cervix through a speculum.

In a certain proportion of the cases, usually those of a severe type with constitutional symptoms, a positive result is obtained by the complement fixation test. When there is arthritis, the gonococcus may be isolated from the blood or the joint fluid. Organisms recovered from extragenital sources must be identified by cultural and immunological methods, for it is impossible morphologically to distinguish between the gonococcus, the meningococcus and *B. melitensis*.

*Prophylaxis.*—The problem of controlling this disease is a difficult one, owing to its highly contagious character, its protracted course and the unsatisfactory results of treatment.

With ambulant patients the home should be investigated to eliminate, if possible, the source of the infection. The most rigid precautions are needed to prevent the patient from infecting others. An infected person should sleep alone, should wear a vulvar pad that can be destroyed; sheets and clothing should be washed separately from those of the household, and special care should be used about towels, bathtubs and the toilet seat. In schools the greatest danger is probably from the common toilet; only the U-shaped toilet seat should be used. Girls should be instructed in the dangers of infection and in precautions needed when using public toilets. It is not justifiable to exclude all infected children from schools. They should, however, be isolated as long as the discharge is abundant, and precautions should be taken to protect other children until they are completely cured.

The problem of prevention is most difficult in institutions. In day nurseries, hospitals and homes for children, admission vaginal smears should be a matter of routine; they should be repeated every week or two. All suspicious cases should be quarantined. The most rigid isolation must be practiced with patients carrying the gonococcus, if epidemics are to be avoided. Attendants should use separate



gowns for each individual case and should remove these and wash their hands immediately on leaving the patient. Napkins, underclothing, sheets, towels and wash-cloths should be soaked in antiseptics or thoroughly boiled. Separate thermometers should be used for each child.

*Treatment.*—The multiplicity of treatments recommended for this disease bears eloquent witness to the fact that the results with none of them have been entirely satisfactory. It has been the usual practice to carry on a vigorous campaign of local treatment consisting of daily hot baths and instillations of a mild antiseptic solution several times a day. Various antiseptics have been used: bichloride of mercury, the colloidal preparations of silver, and, lately, mercurial dyes of one type or another have been popular. Only when such therapy is faithfully carried out can beneficial results be obtained. The majority of the cases can be cleared up in about four months. Relapses are frequent and may occur after months and even years in cases apparently completely cured.

In a small but definite proportion of the cases a chronic cervicitis persists. For this stronger antiseptics such as 20% mercurochrome have been used, and as a last resort, applications of silver nitrate or the cautery.

In recent years the therapeutic approach has been along different lines. Diathermy and fever therapy have been used in a number of clinics with striking results. Carpenter, Warren and their associates at Rochester, using a combination of diathermy and external heat, found that when the thermal exposure was adjusted to the thermal death point of the particular strain of organism, as determined in vitro, success was regularly obtained; it was rarely necessary to give more than one or two treatments. There are, however, practical difficulties in treating very young subjects.

The estrogenic hormone was first used as a therapeutic agent by R. M. Lewis. Its value has since been confirmed by a number of other workers, notably by TeLinde and Brawner at the Johns Hopkins Hospital. The hormone converts the delicate epithelium of the child's vagina into the thicker, cornified type characteristic of the adult, which is relatively resistant to the gonococcus. The hormone is most effective when given locally; only the desired local effect is then obtained, and no untoward effects have been observed. A vaginal suppository containing 75 units is given daily until at least a week after smears have become negative. The characteristic change in the epithelium appears at the end of the second week. In the cases studied in Baltimore smears became negative by the 17th day on the average, the longest duration being seven weeks. Two instances of relapse responded promptly to renewed therapy.

It seems likely that the great majority of patients, even if untreated, will clear up at the time of puberty if they escape reinfection. Whether there is an appreciable percentage in which the infection remains latent in the cervix, where it may flare up in adult life or give rise to ophthalmia neonatorum, is not known. In a study of adult women who had had gonorrheal vulvovaginitis in childhood, Dooley was unable to show that their reproductive history differed from the normal.

**Other Infections of the Female Genito-urinary Tract.**—Besides the forms of vulvovaginitis mentioned, diphtheria, erysipelas and other infections may attack the female genital organs. A rare but serious condition is *noma* (gangrenous



vulvitis). This is the same process as that seen in the mouth, known as cancrum oris. It follows infectious diseases, usually measles, occurring in patients whose vitality is greatly reduced. There is first noticed a tense, brawny induration, the skin being shiny and swollen over a circumscribed area. In the center of this there soon appears, usually upon one of the labia majora, a dark, circumscribed spot. Day by day the gangrenous area advances, preceded by the induration. It may involve the whole labium, extending even to the mons veneris and the perineum. These cases are generally fatal. If recovery takes place, it is with considerable deformity of the parts in consequence of the extensive sloughing and cicatrization. As sequelae, there may be fistula, stenosis, or atresia of the vagina. The only treatment is radical excision with cauterization.

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## CHAPTER LXXXVI

### NEPHRITIS

#### ACUTE NEPHRITIS

**Etiology.**—Acute hemorrhagic or glomerular nephritis is undoubtedly a manifestation of focal infection, although the location of the infection may be difficult or even impossible to determine. Most often, however, it is in the pharynx or tonsils where the infectious agent, usually a hemolytic streptococcus, elaborates a toxin that is carried to the kidneys by way of the blood stream. The cervical glands, middle ear, and mastoid may also serve as the focus of infection. Acute nephritis is frequently secondary to the acute infectious diseases, especially scarlet fever, and follows both mild and severe attacks, even when patients have been kept in bed throughout the disease. The frequency with which nephritis complicates scarlet fever varies greatly in different epidemics but the average is from 6 to 10 per cent. Occasionally skin infections, such as impetigo and furunculosis, lead to the development of nephritis. Occasionally also nephritis occurs in infants with congenital syphilis. In such cases it apparently depends upon secondary invasion of the nose and throat by ordinary pyogenic organisms, the entrance of which has been permitted by the abnormal state of the mucous membrane produced by the syphilitic infection. Syphilis itself is not the etiological agent.

**Pathology.**—Each of the various injurious agents which cause the diffuse damage and reaction in the kidney, designated by the term “acute nephritis,” usually acts with especial intensity upon some particular part of the kidney structure. It is customary, therefore, to speak of acute glomerular, tubular, or interstitial nephritis, according to whether the most prominent visible damage involves the glomeruli, the tubules or the connective tissue framework of the organ. However, the total injury is hardly ever so sharply localized, and in any instance such terms properly define the real situation only in the early stages, or when the damage is very mild; for aside from the fact that functional derangements are not always paralleled by histologically recognizable alterations, severe damage, even if localized to one portion of the histological unit, commonly leads to secondary impairment of the function of the remaining portions. Since the vascular arrangement within the kidney is such that practically all of the blood which supplies the tubules must pass first through the glomerular capillaries, it is obvious that the obliteration of a glomerular tuft will be followed by a disturbance of the function of the dependent tubular epithelium, and if a tubule is destroyed and collapsed the function of the glomerulus attached to it must be interfered with. Finally, death of the parenchyma may initiate a proliferative and reparative activity of the interstitial tissue, and conversely, if the damage affects primarily the interstitial tissue, the parenchyma may be secondarily compressed or injured in other ways during



the inflammatory reaction. In a strict sense then, a pure form of glomerular or interstitial nephritis very rarely occurs; but this classification has, nevertheless, a certain degree of usefulness, for when the histologically recognizable damage is most intense in any one of these situations, it is often possible to correlate that damage with a particular clinical picture and certain changes in the urine and blood chemistry.

In *acute glomerular nephritis* each kidney is usually enlarged, edematous and rather pasty. The capsule comes off easily, exposing a smooth surface. The cortex is thicker than normal, sometimes gray in color and frequently flecked with small hemorrhages. The glomeruli may be conspicuous macroscopically, and microscopically are found altered in a variety of ways. Sometimes there is an enlargement of the tuft, the capillaries of which may be stuffed with mononuclear cells which are usually assumed to arise from local proliferation of the endothelium, but which may quite as possibly be mononuclear cells derived from the blood; polymorphonuclear leukocytes may crowd within the tuft capillaries and escape with albuminous fluid and red blood cells into the capsular space, to be swept on through the tubules out into the urine. The red cells of the small hemorrhages seen macroscopically are usually found not in the interstitial tissue but within tubules and capsular spaces. Since erythrocytes cannot easily enter the tubules from lesions of capillaries other than those of the glomeruli, their presence in the urine in acute nephritis serves as an indication of glomerular damage. Hyaline thrombi may plug the glomerular capillaries, and in the embolic nephritis associated with vegetative endocarditis, small plugs of bacteria and bits of thrombi from the heart valve can be found obstructing loops in the tufts. Part of the exudate of blood cells and albuminous fluid which pours out into the capsular space may coagulate and become fixed there, subsequently to be covered over by a proliferation of the lining cells of the capsule and finally to be replaced by connective tissue. Excessive proliferation of the lining capsular epithelium frequently results in the partial filling up of the capsular space by layers of newly formed epithelial cells. Inflamed loops of the tuft which lie in contact with the side of the capsule become lightly adherent to it at first, and later permanently bound to it by a connective-tissue adhesion. The epithelial cells of the tubules may appear very little altered for a time, but in any severe or protracted case they are invariably swollen, granular, and often contain hyaline droplets and lipoids. They may even drop off into the lumen and become consolidated with albumin and blood cells to form the cellular casts which are found in the urine. In the really acute cases of glomerular nephritis, with the exception of the bacterial form, there is usually only a negligible infiltration of inflammatory cells in the interstitial tissue.

The kidney in *acute tubular nephritis* may appear practically normal macroscopically or it may be swollen, and rather doughy, and pale in color. The surface is smooth. The architecture is not visibly altered. Microscopically the glomeruli appear quite normal except for the presence of albumin in Bowman's capsule, but the epithelial cells of the tubules are found in various forms of degeneration. They may be swollen, filled with globules of fat, and doubly refractive lipoids, speckled with granules and with larger hyaline droplets; they may be necrotic and coagulated, with fading or pyknotic nuclei, still attached to the wall of the tubule or



desquamated into the lumen, forming casts. A few leukocytes and albumin (but only rarely red blood cells) are found within the tubules. The reaction in the interstitial tissue is usually minimal. This is the form of nephritis further described under the heading of Nephrosis.

*Acute interstitial nephritis* is a relatively uncommon condition, which is seen as a complication of sepsis, occasionally in association with diphtheria or other infectious diseases. The kidney is swollen and pasty in appearance. The capsule comes away leaving a smooth surface blotched with many dark red and gray areas. The cortex is swollen, but, in contradistinction to its regular architecture in glomerular and tubular nephritis, the striae are obliterated here and there by streaks and patches of opaque gray often mottled with or bordered by red. Microscopically there is found a more or less dense infiltration of mononuclear cells in foci throughout the interstitial tissue. A few polymorphonuclear leukocytes are scattered among the mononuclear cells; there is inflammatory hyperemia in the area and occasionally small hemorrhages. The glomeruli and tubules may be quite unaffected except that a few mononuclear cells may have wandered into the tubules from the inflammatory foci. In such cases it is obvious that the excretory function of the kidney may be unimpaired and that little information regarding the lesion can be acquired from a study of the urine. Surprisingly extensive interstitial lesions may therefore escape detection during life. On the other hand, in some cases the tubules and glomeruli, caught in the inflammatory area, may be compressed or their cells damaged so that functional and urinary changes become obvious.

Because of the existence of many more functional units than are necessary for the maintenance of life and because of the remarkable capacity for regeneration and compensatory hyperplasia possessed by the cells of the tubules, unless an overwhelming damage occurs suddenly in any one of these three acute processes, enough units are left intact to maintain life until the damage can be repaired and, if necessary, new tissue formed to compensate for that irreparably destroyed. This is the usual outcome. Slight glomerular injuries may heal perfectly but a glomerulus once destroyed cannot be restored to normal. It must remain, thereafter, partially or entirely replaced by connective tissue, and there is no mechanism through which a new glomerulus can be formed to take its place. Tubular epithelium, on the other hand, can regenerate so perfectly that a short time after even very extensive damage, no histological evidence of it can be detected. Inflammatory exudate, too, may be completely removed from the interstitial tissue, leaving no trace of its former presence. However, a severe enough tubular damage or interstitial inflammation will result in the replacement of the normal tissue by scars.

**Symptoms of Acute Glomerular Nephritis.**—*Mild Form.*—This is a very common form of renal disease. It is usually met with in children over three years of age but may occur even in infants. There may be a history of antecedent tonsillitis or pharyngitis; frequently, however, there is none. The onset is relatively acute, although the symptoms may develop gradually over a period of several days. The first thing to attract attention is diminution in the quantity of urine, a change in the color of the urine, slight puffiness of the face or feet or perhaps vomiting. A sharp acute onset with marked constitutional symptoms and fever occasionally



occurs even in the mild forms. The urine is not often greatly reduced in amount and anuria is rare. The urine is of a rather high specific gravity and contains a moderate amount of albumin and casts of all varieties—hyaline, granular, epithelial and blood casts. They are generally not numerous. The amount of blood in the urine is variable. There may be enough to give a smoky color, or even to render the urine grossly bloody. There is some headache, languor, lack of appetite, occasional vomiting and generally marked anemia. There is usually little or no fever. The edema is not a striking symptom and there may be none. Transudation into the serous cavities is uncommon. The blood pressure is usually not increased and the excretion of phenolsulphonephthalein is within normal limits. Uremic symptoms are very infrequent. After a week or ten days of albuminuria, improvement usually begins. The albumin and blood gradually disappear, and in from three to six weeks the urine is clear. Exceptionally the course may be very much prolonged but even when albuminuria and hematuria have lasted several months, recovery is usually complete. Chronic nephritis following a mild form of acute nephritis is rare.

*Severe Form.*—This may be apparently primary or frankly secondary. The onset may be gradual as in the mild form but is frequently sudden. The first symptoms may be dropsy or, without this, headache, vomiting, scanty urine, fever and even convulsions may appear abruptly. While edema is usually present, it may be slight or absent in severe and even in fatal cases. It is first seen in the face, next in the feet, legs and scrotum; there may be general anasarca with effusion into the serous cavities, the pleura, or the peritoneum, rarely the pericardium. Vomiting may be frequently repeated and diarrhea may be present. Patients are often somewhat drowsy and confused. The eyegrounds may show papilledema and retinal hemorrhages, with patches of exudate. The temperature generally ranges from 100° to 101.5° F., but in very severe attacks it may be 104° or 105° F.

The urine is, as a rule, greatly diminished in quantity, and may be suppressed. Albumin is invariably present; it is usually in large amount, often enough to render the urine solid on boiling. The urine is dark reddish brown or smoky in color. The specific gravity is usually high, 1.020 to 1.030. Casts are present in great numbers, chiefly hyaline, granular and epithelial casts; not infrequently there are blood casts. Red blood cells are very numerous, as are leukocytes and renal epithelial cells. Unless there is great diminution in the quantity of urine the elimination of phthalein is usually within normal limits. In very severe cases there may be a retention of nonprotein nitrogen in the blood but in many fatal cases there is none. Phosphate and sulphate retention, with diminution of the serum total base and bicarbonate and resultant acidosis, occurs in severe cases. The systolic pressure is frequently elevated to some extent and it may be 150 millimeters or more even without definite uremic symptoms. When uremia is present it is invariably raised. Myocardial failure sometimes occurs as a secondary effect of the sudden elevation of blood pressure, and this may be the immediate cause of the child's coming to the hospital. As the disease progresses there is always a very marked degree of anemia.

The duration of the active symptoms in cases terminating in recovery is from one to three weeks. The temperature and dropsy gradually subside. Clinical improvement is usually preceded by an increase in the quantity of the urine and by a



diminution in the amount of blood, albumin and the number of casts. A few casts may persist for several weeks, and a small amount of albumin for two or three months. Casts and albumin may, however, persist in the urine for many months and yet complete and permanent recovery take place. The McClure-Aldrich test, the disappearance time of a wheal of normal salt solution injected intradermally, shows an alteration proportional to the degree of edema. In normal patients the wheal persists for some forty-five minutes; with anasarca it disappears almost immediately after injection. A prolongation of the disappearance time of the wheal in the McClure-Aldrich test sometimes precedes the subsidence of edema and has in this respect some prognostic value.

Symptoms of uremia may appear at any time in the course of acute nephritis, usually in the first week. Occasionally they are seen within a few hours after the onset. This is usually when there is anuria at the very beginning of the attack. Care should be taken not to mistake bladder retention for suppression.

Symptoms of uremia are manifested in children by vomiting, great restlessness, headache, dimness of vision, stupor developing into coma, and convulsions. There is always a high systolic pressure—140 to 180 millimeters or more. A progressive increase of blood pressure is always a signal of danger. The nonprotein nitrogen may be greatly increased but not regularly so. It may be 80 to 100 milligrams per 100 c.c. The urine is greatly reduced in amount. If the secretion of urine is reëstablished, the nervous symptoms abate and the patient usually recovers. This has been known to occur after complete suppression has lasted two days or more. Death may take place in convulsions when there is not complete suppression or in coma after several days of uremic symptoms. If the period of uremia is survived the disease runs the course of the ordinary severe type as described above. Death may occur early from myocardial failure or later from some other complication, the most frequent being pneumonia. Edema of the glottis is exceedingly uncommon in children.

**Prognosis.**—This is to be considered from two points of view: first, the danger to life during the acute stage of the disease, and, secondly, the danger of the development of chronic nephritis. The majority of patients survive the acute stage; very frequently even those recover who have presented grave symptoms of uremic poisoning. The existence of acidosis and of severe nervous symptoms, such as stupor, intense headache, dimness of vision, persistent vomiting, a high blood pressure and other manifestations of uremia, add much to the gravity of the case, as does also the presence of any serious complication. In general it may be said that if there is no suppression of urine, or if there are no symptoms of uremia and no complications, recovery is almost certain. The total mortality during the acute stage among patients followed by Guild in the Harriet Lane Home with this form of nephritis has been approximately 3 per cent. Statistics from cities farther north, such as New York and Boston, have shown a somewhat higher mortality.

In regard to the ultimate prognosis, the outlook is equally good. Although the idea was prevalent at one time that acute nephritis was frequently followed by chronic disease of the kidney, more recent experience has shown that this outcome is decidedly uncommon. In both mild and severe cases complete recovery is the rule. In most of them the urine clears within two months, although complete



clearing may still take place after abnormal constituents have been present for as long as a year. Recovery seems to be more prompt in younger than in older children; that is, in children under eight years of age.

Recurrences with subsequent infections are relatively infrequent, and there is some reason to believe that removal of foci of infection lessens this infrequent tendency to recurrence. Considering the frequency of acute nephritis, it is remarkable how few cases of serious chronic nephritis are observed. Even when albuminuria persists for years, a good state of health and of kidney function is in most instances maintained.

**Treatment.**—Prophylaxis is important and consists mainly in keeping the child in bed throughout the febrile stage of any acute infection, although there is no certainty that this will prevent the complication of nephritis.

Complete rest in bed is also of the utmost importance when the nephritis has once developed, even if the attack is mild. During the first few days the patient should be kept on a bland diet, mainly of milk and farinaceous foods. Continued restriction of the diet is, however, unnecessary, excepting in very severe cases where the patient is too ill or disinclined to take much food. As the appetite returns a general diet can gradually be resumed with avoidance only of highly seasoned or obviously indigestible foods. Fluids should be given freely throughout, irrespective of the extent of the edema.

The mild cases tend to spontaneous recovery under the treatment outlined, *i.e.*, rest in bed, a bland diet, and large quantities of fluid. These measures should be continued as long as the urine contains any considerable amount of albumin and until the red blood cells have largely disappeared. Exercise should be resumed gradually and exposure to infections and to inclement weather avoided as long as possible.

The severe cases with scanty urine, fever and marked dropsy require more active treatment. Two or three loose movements from the bowels should be secured by the administration of magnesium sulphate. Harm is sometimes done by carrying this depletion too far, and its effect upon the patient's general condition must be closely watched.

Blackfan and Hamilton have shown that the blood pressure may be reduced and the symptoms of uremia often satisfactorily controlled by the use of magnesium sulphate intravenously. A 1 per cent solution of the crystalline salt is injected slowly at the rate of 2 c.c. per minute. The amount employed is 10 to 15 c.c. per kilogram of body weight. Determinations of the blood pressure are made during the course of the injection and if a considerable fall occurs the injection is stopped. The duration of the effect is five to ten hours. If the blood pressure rises again the injection should be repeated. Three or four injections may be required. Many of these patients respond well to large doses of magnesium sulphate given by mouth, as Aldrich in particular has emphasized. Its cathartic effect is less than one would expect in other patients, often remaining absent. Magnesium sulphate has no effect upon the course of the nephritis.

The nervous symptoms of uremia are best relieved by chloral, which can be given by rectum if there is difficulty in administering it by mouth. When such symptoms are marked, from 6 to 10 grains are required for a child of five years,



to be repeated in two hours if no improvement is seen. Uremic convulsions may sometimes be averted by the use of morphine hypodermically. Diaphoresis by the hot pack should be used guardedly as it may be badly borne, but the continuous tub often relieves the uremic mania better than any drug. Lumbar puncture gives temporary relief in some cases.

One should always be on the lookout for complications, such as peritonitis, pericarditis, pulmonary edema from myocardial failure, and pneumonia. Convalescence is nearly always slow, and a patient who has suffered from a severe nephritis needs careful attention for a long time. Anemia is always present and must be combated by appropriate dietetic measures, medicinal iron, or sometimes by transfusion. The average diet for normal children does not contain an excess of protein, and need not be altered in this regard; it is, however, important to avoid renal irritants such as pepper, mustard, catsup, flavoring sauces and highly seasoned foods. Chilling must be guarded against, which for older children means prohibition of swimming and outdoor bathing for some months after the attack. If there is a recurrence, or if the disease tends to pass into a subacute form, the child should, if possible, be sent to a warm climate and kept there during the succeeding winter. Every effort should be made to protect him from superimposed infections of all sorts, but particularly colds and other respiratory infections.

### NEPHROSIS—TUBULAR NEPHRITIS

This condition, which superficially resembles true nephritis, is distinguished by three clinical features, namely, the blood pressure is usually normal, there are never more than a few transient red blood cells in the urine and the course, though often prolonged, usually ends in recovery. Much of the confusion in regard to nephrosis and nephritis is probably due to differences in definition, but we believe that the two can be differentiated clinically on the basis just described.

**Etiology.**—Clausen and Marriott have called attention to the fact that focal infection in the nasal sinuses or mastoids may be responsible for a number of cases of nephrosis. In our experience, no one organism can be incriminated, nor is it possible always to demonstrate a focus of infection.

**Pathology.**—Thirteen of 33 patients with nephrosis in the Harriet Lane Home, analyzed by Tappan, died of intercurrent infections. The anatomical findings in these cases confirm those reported by other authors. The kidneys are greatly enlarged and pasty in consistency. The capsule is not adherent and the surface is smooth. The cortex is pale yellow in color, flecked with many bright yellow opacities. Microscopically, the glomeruli in some cases are entirely normal in appearance save for the presence of albuminous material within the capsular spaces. In others an occasional glomerulus shows minor changes in the form of small intracapsular adhesions with slight cellular infiltration. The interstitial tissue is likewise normal excepting for an occasional scar. The most characteristic changes are in the tubules, which are everywhere dilated and lined by low flat epithelium containing large amounts of doubly refractile lipoid. Here and there small masses of necrotic, coagulated tubular epithelium are found; occasionally the tubular epithelium is swollen and granular. There are hyaline casts and much albuminous material within the



tubules and a few of them contain fresh red blood cells. Although the anatomically recognizable damage is confined almost exclusively to the tubular epithelium in these cases, the presence of blood in the tubules suggests slight glomerular damage as well. Cases of long standing may show some anatomical changes in the glomeruli.

**Pathogenesis.**—The edema of nephrosis was once attributed to retention of salt and water, a view no longer tenable. More acceptable is the explanation, first offered by Epstein, that edema is due to depletion of blood protein as a result of loss of protein in the urine. In experimental animals anasarca can be regularly produced when the blood protein is lowered by *plasmapheresis*—removal of blood and replacement of the red cells suspended in saline. As the condition clears up—both in human nephrosis and in experimental plasmapheresis—there is a definite parallelism between the diminution of the edema and the rise in serum proteins. One can scarcely doubt that secondary changes in electrolyte distribution resulting from low plasma protein play an important part in causing the edema. However, the observation has been made more than once that subsidence of edema may precede a rise in the plasma proteins, which suggests that other factors, as yet unknown, are also involved.

**Symptoms.**—These patients are generally brought to the hospital because of the presence of edema. This may develop without any preceding infection, or, as is frequently the case, may appear shortly after an acute, usually upper respiratory, infection. Ordinarily the onset of the edema is insidious, occasionally very rapid; at times it is steadily progressive, at others it undergoes marked daily fluctuations. Nausea and vomiting often usher in the attack, which is accompanied as a rule by suppression of urine. Extreme degrees of edema may be seen, the eyes being closed, the legs swollen, marked ascites being present and, in males, the scrotum being distended with fluid. In spite of the edema, unless this be extreme, the patients are often comparatively comfortable and have a fair appetite. This disproportion between the degree of edema and the constitutional symptoms is in contrast to the prostration often exhibited by edematous patients suffering from acute nephritis. The blood pressure and the eyegrounds usually remain normal, though there may be some retinal edema.

The urine is usually reduced in amount and contains a large quantity of albumin, 10 to 12 grams per liter in some instances, with white blood cells and varying numbers of hyaline, granular and epithelial casts. Fixation of specific gravity is not found. Doubly refractile bodies can be demonstrated in the urine and Clausen has described a substance which lowers surface tension. A few red blood cells are found in at least half of the cases, but appear intermittently and never in great numbers. The kidney function tests are normal and there is no retention of nitrogenous products in the blood. During periods of edema, the chlorides and cholesterol of the blood are usually increased, the total proteins diminished, the normal albumin-globulin ratio is reversed, and the surface tension of the plasma may be lowered. The serum calcium is often low, as a secondary result of the low serum protein, but tetany rarely occurs even with very low values, since the portion of serum calcium bound by protein is normally inactive.

The edema may persist for several days and then gradually disappear and at the end of two to three weeks the patient may be quite normal in appearance. In



other cases, the accumulated fluid may subside in two or three days, the amount of albumin in the urine may diminish markedly, and occasionally the urine may become albumin-free. In many instances, however, the edema does not entirely disappear even after several weeks and an appreciable amount of albumin remains in the urine. The severity of the edema usually follows the level of the plasma proteins, increasing when the concentration of the latter falls. Whether the edema entirely disappears or not, there are frequent periods, weeks or months apart, in which exacerbations occur. Probably the majority of these are ushered in by a respiratory infection. One of our patients had at least eleven such episodes during a period

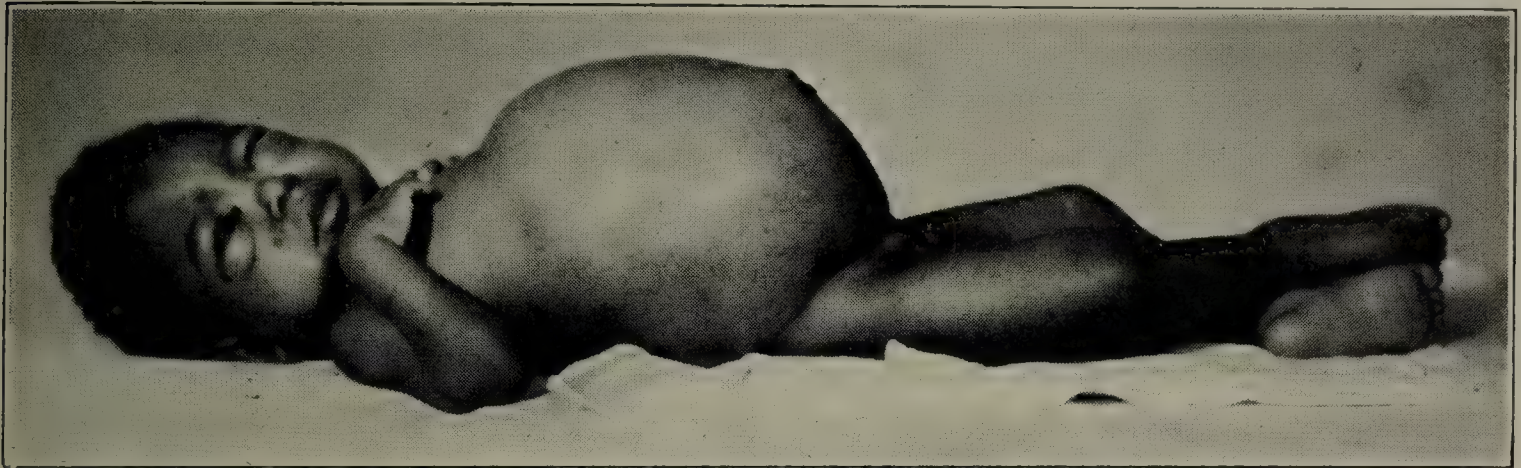


FIG. 112.—NEPHROSIS.

James C. (B.H. 317668) developed measles and whooping cough at two years and three months of age. Edema of the face first appeared three months later and rapidly spread to the entire body, producing ascites which required relief by abdominal paracentesis. The urine contained large amounts of albumin and casts and a few red cells. Blood nonprotein nitrogen 27 milligrams per 100 c.c.; cholesterol 0.39 per cent; serum albumin 1.4 per cent; serum globulin 1.1 per cent. High protein diet and large doses of thyroid extract failed to control the progressive anasarca, and two further paracenteses were required, at each of which about 2500 c.c. of fluid were removed. At the age of two years and nine months he developed pneumococcus (Type IV) peritonitis and died.

of five years and spent a total of twenty-four months of this time in the hospital. At times she remained free from edema for as long as twelve consecutive months, although albumin never entirely disappeared from her urine; at other times she was more or less edematous for periods of one to four months.

Uremia does not occur. In two patients, in whom there were convulsions at irregular intervals for several days, the convulsions seemed to bear no relation to the presence of edema nor could they be explained on the basis of any change in the constituents of the blood.

**Prognosis.**—The ultimate prognosis in nephrosis is good provided the patient does not succumb to an infection. It must be emphasized, however, that the condition is chronic and that several years may elapse before the patient may be permanently free of edema and albuminuria. Of the 33 cases analyzed by Tappan, 13 died from infections, 8 recovered completely from five to eleven years after the onset of the disease, while 6 others, although still showing albuminuria, are at present symptomatically well after six months to eleven years. The remaining 6 continue to suffer relapses of their edema, but are maintaining a normal kidney function.

Intercurrent infections are the usual cause of death, particularly *pneumococcus*



infections, either generalized or in the form of a peritonitis. The frequent association of pneumococcus peritonitis with nephrosis is very interesting and at present not understood. It is not necessarily fatal, when occurring independently of a generalized infection, but was the terminal event in 7 of our cases, while 4 others survived from 1 to 4 attacks, either dying later of some other infection or progressing toward recovery. In most cases the peritonitis occurs during periods of edema, although the edema may temporarily disappear during the course of the attack. A temporary disappearance of edema has also been seen to occur during an attack of measles and in another instance during the course of an erysipelas. The low resistance of the patient to infection during exacerbation of the disease, and the ever-present menace of a pneumococcus peritonitis in particular, renders the prognosis uncertain in any case, in spite of the favorable outlook from the standpoint of the kidneys themselves. In patients with severe anasarca, trophic ulcers afford a ready portal of entry to infections.

**Treatment.**—Foci of infection should be cleared up as completely as possible. A thorough examination of the nasal accessory sinuses should be made and if they are infected they should be drained. The protein of the diet should not be restricted, since depletion of the body proteins is manifested in the massive proteinuria and the diminution of these substances in the plasma; yet a high protein diet ordinarily has no other effect than to increase the amount lost through the kidneys and, in our experience, has not significantly altered the course of the disease. The water intake need not be restricted, and no particular restriction of the diet seems to influence the outcome. Purgation has not been of much help. Diuretics such as theobromine sodium salicylate (diuretin), and less often thyroid extract in large doses, will sometimes cause a loss of edema but the fluid usually reaccumulates as soon as the drug is discontinued. Many patients respond well to transfusion, particularly to repeated small transfusions; their mode of benefit is obscure. The utmost care is required in protecting these children from superimposed infections; although at times, as pointed out above, a febrile illness may cause the edema to disappear with miraculous rapidity, the patient's subsequent state is often far worse. Relief of edema by scarification or the subcutaneous implantation of drainage needles is not to be encouraged on account of the low resistance to infection.

There is no standard method of treatment of pneumococcus peritonitis; we have seen several patients die with it, others recover after surgical drainage, and still others recover when nothing is done. When there is reason to suspect a pneumococcus peritonitis, it is always advisable to aspirate a small amount of fluid for diagnostic purposes. Unless, however, there is a large enough accumulation to cause real discomfort to the patient, experience has led us to believe that it is best to do nothing further. If, for relief of symptoms, it becomes necessary to withdraw some of the fluid, it is best to do this by means of a small trocar rather than by surgical incision and drainage.

### SUBACUTE PARENCHYMATOUS NEPHRITIS

There is another small group of patients, who are best classified separately under the heading of *mixed nephritis*, since they present a clinical picture that



combines the outstanding characteristics of an acute glomerular nephritis and nephrosis. At the time that they come under observation it is impossible to say from the history given or from an analysis of the clinical findings and laboratory data whether the disease started as an acute hemorrhagic nephritis or as a nephrosis, and it seems probable that the two conditions were combined from the start.

**Pathology.**—The kidneys are normal in size or swollen, with smooth or slightly granular external surfaces. They are pale or slightly yellowish, flecked with minute hemorrhages and yellow opacities. On section the cortex is not narrowed, but the normal striae are not distinctly visible. Microscopically the glomeruli are involved, many of them obliterated and scarred, others in a less advanced stage are surrounded by mantles of a cellular tissue produced by proliferation of the capsular epithelium following the organization of exudate or hemorrhage into the glomerular capsule. The tubular epithelium is swollen and granular, the cells contain lipid droplets, some of which are doubly refractile, and necrosis can be found. Scattered tubules contain fresh or old blood; others, more numerous, contain casts, and in a few cases tubules are filled with a fresh or old exudate of leukocytes. Other tubules are dilated and lined by a low flattened epithelium. Fat in varying quantity can be demonstrated in both the damaged glomeruli and the tubular epithelium. In the interstitial tissue a loose, cellular, fibrous scar tissue, richly infiltrated with lymphocytes and mononuclear cells, replaces the totally destroyed tubules or separates atrophied narrow tubules, the glomeruli of which are represented by scarred, contracted masses. The scarring may be more extensive than the size and smoothness of the kidney would seem to indicate.

**Symptoms.**—As in nephrosis the onset is usually insidious. It cannot, as is usually the case in acute nephritis, be dated with any accuracy. Edema is the complaint that ordinarily brings the patient to the hospital, and it is discovered in taking the history that some puffiness of the eyes had been noticed for a number of months before the edema was sufficiently marked to disturb the patient. Until shortly before admission the child had not seemed much below par and had not really been regarded as sick.

At the time of examination the edema is usually so striking that one suspects a diagnosis of nephrosis. The blood pressure is, however, slightly elevated, there is a moderate grade of anemia, and the urine reveals many red blood cells, often frank hematuria in addition to the large quantities of albumin characteristic of nephrosis. There is also a low serum protein with inversion of the albumin-globulin ratio. There is a slight elevation of the nonprotein nitrogen of the blood and often a slight diminution in the two-hour phthalein excretion.

The disease is characterized by remissions and exacerbations of the edema and hematuria, by slow but progressive impairment of kidney function as evidenced by a decrease in the phthalein excretion and continued increase in nitrogen retention, and by a definite elevation of blood pressure, if this was not already present when the patient came under observation. Albumin never disappears from the urine, even during the remissions in symptoms, although it is less in amount at such times. Infection, particularly a pneumococcus peritonitis, may supervene at any stage, as in nephrosis, or the condition may progress into one of chronic renal insuffi-



ciency with all the symptoms of chronic nephritis, as described under that heading.

**Prognosis.**—The prognosis in this form of nephritis is almost uniformly bad. If the patient does not die of intercurrent infection, he is almost certain to die of renal insufficiency. In 9 of 12 such cases analyzed by Tappan, death occurred from six months to five years after the patients first came under observation. The 3 survivors were showing evidence of progressive renal damage when last seen.

### CHRONIC NEPHRITIS

Chronic nephritis (contracted kidney) is fortunately a relatively uncommon occurrence in childhood. Instances in which the kidney tissue is destroyed by back pressure resulting from malformations (hydronephrosis) or chronic infections (pyonephrosis) are discussed elsewhere. There remains a small group of cases showing progressive evidences of renal insufficiency during life and contracted kidneys at autopsy, the origin of which is not altogether clear.

**Pathology.**—The kidneys present a picture in striking contrast to the subacute nephritis described above. The organs are broken up into coarse lobules by wide, depressed scars, isolating the projecting, paler masses of better-preserved renal tissue. In a case which we have recently seen, one whole kidney was a small, shrunken mass and one pole of the other was largely made up of scarred, tough, red tissue. Microscopically, the scarred areas are marked by the most extensive destruction and fibrosis, with concentrated hyaline glomeruli and great reduction of the tubules. The scars are often thickly infiltrated with lymphocytes. In the better-preserved areas there is great dilatation of the tubules; the glomeruli in these areas give no indication of a progressive destructive inflammation.

These cases have often been regarded as the terminal stage of the various forms of acute and subacute nephritis described above. While reports from the literature would seem to indicate that this may occasionally be the case, it seems likely that this picture is more often produced by an extensive pyelonephritis at some early age, in which the infection itself has died out, but only after causing widespread destruction of renal tissue. The remaining parenchyma may be sufficient for the child at the time, but is inadequate for his increased needs as he grows. In support of this view is the fact that most of these cases occur in girls. The pelvis and ureter are usually thickened, and a careful search may show microscopic evidences of inflammation in the ureter and lower urinary passages.

Vascular changes in the kidney are not conspicuous in these cases, although they have been described. There may be hypertrophy of the heart with or without dilatation.

**Symptoms.**—The basic syndrome of chronic renal insufficiency is present in all these cases, nor can they be differentiated symptomatically from renal failure due to progressive infections, malformations or other causes.

In the few cases developing out of attacks of acute nephritis, particularly the mixed nephritis, and in others where acute nephritis is superimposed on a pre-existing chronic nephritis without edema, anasarca is often one of the striking features. In some patients it is nearly constant in degree; in others it fluctuates greatly from time to time. It may be present for months or years. There are



various digestive symptoms, often more marked than in uncomplicated forms. Loss of weight may be masked by the edema. The eyegrounds often show marked changes—edema of the disk and of the entire retina, retinitis, hemorrhages, even detachment of the retina. Headache may be practically constant, and anemia is always marked. In some cases the heart is not enlarged nor is the blood pressure greatly elevated. The urine always shows more conspicuous changes than in uncomplicated cases: albuminuria, red cells, leukocytes, and casts. Neither the specific gravity nor the phthalein excretion, however, may be greatly altered at first. Nitrogen retention may be less marked. As time goes on, however, if these patients survive, the picture goes over to that of severe renal insufficiency with nitrogen retention, and death occurs from intercurrent infection, to which they are particularly liable, or from uremia.

In the more usual forms originating from congenital malformations with or without infection, and in those rare cases which appear to result from a played-out infection that has caused widespread destruction, the development of the clinical picture of chronic nephritis is quite insidious. Attention may be directed to the health of the child on account of pallor, headaches, shortness of breath, poor vision, or vague digestive symptoms. The nutrition is poor; and some are also stunted in growth to such an extent that the term "renal dwarfism" has been applied to them. This is particularly true of those whose disability is based on a congenital malformation and whose physiological and chemical processes have been abnormal throughout the entire period of growth; they show the changes in inorganic metabolism and bone development described under Renal Rickets. Digestive symptoms are often prominent; the appetite is poor, the breath often foul, vomiting and diarrhea occur from time to time, or there may be obstinate constipation. Anemia is striking. The heart is sometimes hypertrophied. The blood pressure may be high, but in many instances is not elevated at all. We have seen one girl of ten with a blood pressure of 180 millimeters which persisted for several months and then fell to below 130 millimeters and remained there for more than two years. Headache is common and troublesome, particularly in children over five years of age. Toward the end it may be constant and associated with stupor. Fatigability is usually marked. There is little tendency to edema unless cardiac insufficiency occurs. Albuminuric retinitis and retinal hemorrhages are uncommon. Convulsions often occur toward the close of the disease. Unless the child succumbs to some intercurrent infection, death usually results from uremia or from cardiac failure, rarely from cerebral hemorrhage.

The urine in these cases is large in amount, pale, with a low fixed specific gravity, around 1.006 to 1.010. Albumin is usually small in amount; at some examinations it may be absent. Casts are not numerous and are hyaline or finely granular. There may be a few red blood cells from time to time, and occasionally leukocytes. The phthalein excretion is interfered with, sometimes to a marked degree. One child under our observation excreted in two hours less than 5 per cent of the injected amount at each test over a period of three years. There is also a marked diminution in urea excretion. Blood analysis shows an increase not only of total nonprotein nitrogen but of all the individual components, urea, uric acid and creatinine. Phosphates and sulphates are likewise retained, and there may be



acidosis, particularly in the terminal stages. The changes in the blood electrolytes are discussed elsewhere (page 53).

**Prognosis.**—The prognosis in chronic nephritis with nitrogen retention and without edema is absolutely bad, but as to the duration no exact statement can be made. Some children, if carefully treated, may survive for years, even with a high degree of renal insufficiency. The onset of marked uremic symptoms usually means a speedy termination.

Patients whose clinical picture is related to some infection, either at the onset or occurring during the course of the disease, have a somewhat more favorable prognosis on the whole, though it must still be guarded. There is always a chance that with the removal of a focus or the subsidence of a superimposed acute process the underlying renal insufficiency may largely disappear. In some cases of urethral obstruction with bilateral hydronephrosis and pyelonephritis, relief of the infection and removal of the obstruction has appeared to bring about a complete restoration of function. It is, therefore, important in all cases of chronic nephritis to determine the presence or absence of some mechanical obstruction as a possible basis for the condition.

In some patients, particularly those in whom the onset has been insidious and the discovery of the condition based on routine physical examination or on the investigation of vague symptoms such as headache or anemia, it is not possible at one examination to make any forecast of the course. The most that one can do is to make a careful study of the patient and determine the present condition of affairs by renal function tests, then at the end of a few weeks or months repeat the entire examination. If in the interval there has been improvement, one may hope that it will continue; if not, the ultimate prognosis is bad.

**Treatment.**—Children with chronic nephritis are to be treated on the same general plan as adults. The purpose of treatment is to retard as much as possible the progress of the disease and to relieve the symptoms as they arise. It is of the greatest importance to remove the patient from conditions in which exacerbations are likely to occur, infections and chilling. If it is possible, he should be sent to a warm dry climate in winter, and all exposure to cold avoided; an outdoor life is desirable, and his human contacts should be limited and carefully supervised, particularly for his protection against respiratory infections. Most patients require general tonic treatment with very moderate but regular exercise, never carried to the point of fatigue, and as much rest as possible in a recumbent position. It is doubtful whether restriction of the protein in the diet has any effect on the course of the disease, although it may be advisable to give only milk for a short time. Iron is theoretically indicated, but in most cases accomplishes very little. Dropsy may call for symptomatic treatment as in nephrosis. If uremia develops, with high arterial tension and stupor, headache and convulsions, it should be treated as described under Acute Nephritis, although some temporary relief of symptoms is the most that any form of treatment can be expected to offer at this stage. Decapsulation of the kidney is to be considered for patients who are growing progressively worse in spite of medical treatment. The immediate risks of the operation are rather less than would be expected. We have seen striking temporary benefit in several cases when this operation was done upon young children. In no



case, however, was the improvement permanent, all the patients dying within a year after it was performed.

The treatment in cases of malformation of the urinary tract has been discussed elsewhere, but the importance of investigation for possible mechanical obstruction cannot be overemphasized, since relief of such obstruction may result in restoration of function to otherwise hopelessly damaged kidneys.

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## CHAPTER LXXXVII

### NEOPLASMS OF THE GENITO-URINARY TRACT

*Tumors of the kidney* are the only ones which occur with sufficient frequency to be of importance. Taken together with those originating in the suprarenal, which are sometimes indistinguishable clinically from those that arise in the kidney, they constitute the most common malignant neoplasms of early life. The great majority of renal tumors belong to the class of *embryonal adenosarcoma*, often incorrectly called "sarcoma of the kidney." Arising from fetal rests, they may contain different types of tissue exhibiting different degrees of differentiation, and may vary in their rate of growth. As a rule they develop in the first five years of life. In Wollstein's series more than a third were recognized in the first year. At first surrounded by a fibrous capsule, the tumor tends eventually to break through this boundary, so that finally the whole kidney may be infiltrated as well as other contiguous structures. It may grow from any part of the kidney and may distort it in various ways. Many of these tumors are hard; others are soft and vascular. The consistency is rarely uniform throughout, and even the firmest mass is likely to contain fluctuant areas of necrosis or hemorrhage. True metastasis is rare, but the malignant character expresses itself in infiltration and direct extension. By invasion of the renal vein the tumor has been known to extend by continuous growth as far as the heart. Pressure symptoms may arise because of the tumor's relation to the diaphragm, the digestive tract, the urinary tract or the great veins. In some instances the growth reaches enormous size; in one of our cases the excised mass weighed 3750 grams (more than 8 pounds).

In the majority of cases no symptoms are noticeable until the tumor is palpated. Its presence is often discovered by the parents but only after it has reached considerable size. Local pain and hematuria sometimes attract early attention. As a rule, anemia, cachexia, and pressure symptoms giving rise to dyspnea, severe constipation, frequent urination, or edema appear relatively late. At first resembling simply an enlarged kidney, the mass grows forward and downward, losing its mobility as it infiltrates and becomes attached to the parietes and to other organs. Tumors arising in the left kidney are often mistaken for an enlarged spleen. Differentiation from cystic kidney or hydronephrosis is sometimes more difficult. Pyelography usually shows encroachment by the mass on some part of the renal pelvis. Although gross hematuria is rare, microscopic blood appears from time to time at irregular intervals.

Some of these growths have been removed successfully. In Wollstein's series of 18 operated cases, 1 patient was alive six years after operation; another lived to adult life. Of 10 cases operated on at the Johns Hopkins Hospital, 1 was reported "well" two years later. Operation should always be performed, and the entire mass, including of course the kidney, removed if feasible. Biopsy is not



justified. It has been shown that the tumor is relatively sensitive to x-ray and radium, and every effort should be made by such means to prevent local recurrence. Some authorities recommend preoperative radiation as well. It must be admitted that in most instances local recurrence of the tumor develops within a few months. In the average case the time of survival after the mass first appears is not over ten months.

Benign tumors are very rare. Only three are described in the extensive study made by Aldibert.

*Adrenal tumors* are often mistaken for those of renal origin. These are usually *neuroblastomata*, and they represent the usual form of so-called retroperitoneal sarcoma in young patients. Unlike the kidney tumors they show a marked tendency to metastasize, and in a characteristic way. Those arising in the left adrenal form secondary growths on the surface of the skull and in the orbit (Hutchinson's type), constituting a common cause of exophthalmos. Those arising in the right suprarenal rapidly invade the liver (Pepper's type), often causing great enlargement. In most cases there is some degree of mixture of these two types. Metastases to retroperitoneal lymph nodes, to the opposite adrenal, to the lungs and to long bones are common and may occur at an early stage before the primary neoplasm is detectable clinically. Local infiltration also occurs with great rapidity. The kidney may be either compressed or actually invaded. Hematuria is somewhat less frequent than in the case of embryonal adenocarcinoma of the kidney. As in the case of the latter tumor, adrenal neuroblastomata vary greatly in size, shape, and consistency. They may also give rise to pressure symptoms. Anemia and cachexia appear relatively late, as is true in virtually all malignant neoplasms of childhood. Asthenia may, however, be an early symptom.

These tumors are rarely operable, since metastasis and local invasion advance so rapidly. They are resistant to radiotherapy. The prognosis is invariably grave.

Precocious sexual development is sometimes associated with tumors of the adrenal—as a rule, not with neuroblastomata but with other more rare forms.

*Bladder tumors* in children are described in the monograph of Albarran and in occasional reports by other authors. Embryonic tumors are the most frequent. Papillomata have been described. The youngest case seen in the Johns Hopkins Hospital was in a boy fourteen years of age.

*Tumors of the ovary* represent approximately 1 per cent of all tumors in childhood. Wiel, in 1904, reported 60 cases of ovarian tumor occurring under ten years of age, of which 24 were under five years. Downes, writing in 1921, collected 21 additional cases in children reported since Wiel's survey. A large proportion appear to be malignant. Torsion of the pedicle, giving a clinical picture easily confused with acute appendicitis, has in several instances called attention to the condition. We have seen removed at operation a benign ovarian cyst which lay free in the peritoneal cavity of an infant of two months, after spontaneous amputation of the pedicle at an unknown date.

*Sarcoma of the cervix* has been observed several times in children. The symptoms do not differ from those in the adult. *Teratoma of the testicle* is the commonest neoplasm affecting the external genitalia but is very rare.



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## CHAPTER LXXXVIII

### SEXUAL PRECOCITY

This is more common in females, but may occur in either sex and at any age. All the changes characteristic of puberty may develop, including sex consciousness and evidences of attraction for the opposite sex. Most of these cases are associated with neoplasms, either of the gonads, the adrenal cortex, the pituitary or the pineal body. In males adrenal tumors are the most frequent cause; in the female, tumors of the ovary. Precocity due to the pituitary is rare in either sex; the few instances associated with pineal tumors have all been in males.

Not all instances of precocity can be attributed to neoplasms. A number of cases are on record in which female infants and young children developed no evidences of neoplasm even after years. Such cases must be attributed to an imbalance of the internal secretions. In some instances a retrogression of the secondary characters has been observed after a few years with normal reappearance at the time of puberty. In others the manifestations continue.

A guarded prognosis must be given in all such cases of precocious puberty, for a neoplasm may be present and yet not declare itself at once. The most common lesion in the female is a granulosa-cell carcinoma. The true nature of these tumors has only been appreciated in recent years; in earlier reports they have been described under a variety of names, being usually regarded as sarcomata. This tumor is of a low grade of malignancy and may give no local symptoms until a year or two after the onset of the precocious sex development. If the symptoms have persisted two years or more, it is unlikely that a neoplasm cannot be detected. In a number of instances these growths have been successfully removed with disappearance of the secondary sex characters and with no recurrence of the tumor. Endocrine therapy has met with little success in any of these cases, although more is to be expected in the future. In young girls there is a very real danger of pregnancy. A temporary tubal sterilization is desirable if there is difficulty in controlling the patient.

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## CHAPTER LXXXIX

### MECHANICAL INJURIES TO THE GENITO-URINARY TRACT

These are decidedly uncommon in children. Rupture of a greatly distended bladder may occur. Prolapse of the bladder has been observed in females associated with dysentery and marked rectal tenesmus. The condition is treated as in adults. Foreign bodies are not infrequently introduced into the urogenital tract. In the bladder and urethra they usually give symptoms resembling a urinary calculus. A foreign body may be the cause of a chronic vaginal discharge.

*Strangulation of the penis* is sometimes seen in older children who pass constricting bands over the organ for auto-erotic purposes. In young children the most frequent cause is an heroic attempt on the part of the mother to control bed wetting by tying a string or thread around the organ at night. There develops priapism and marked edema, which may in some instances obscure the constricting band. If the constriction is relieved before ulceration has taken place the organ returns quickly to normal.

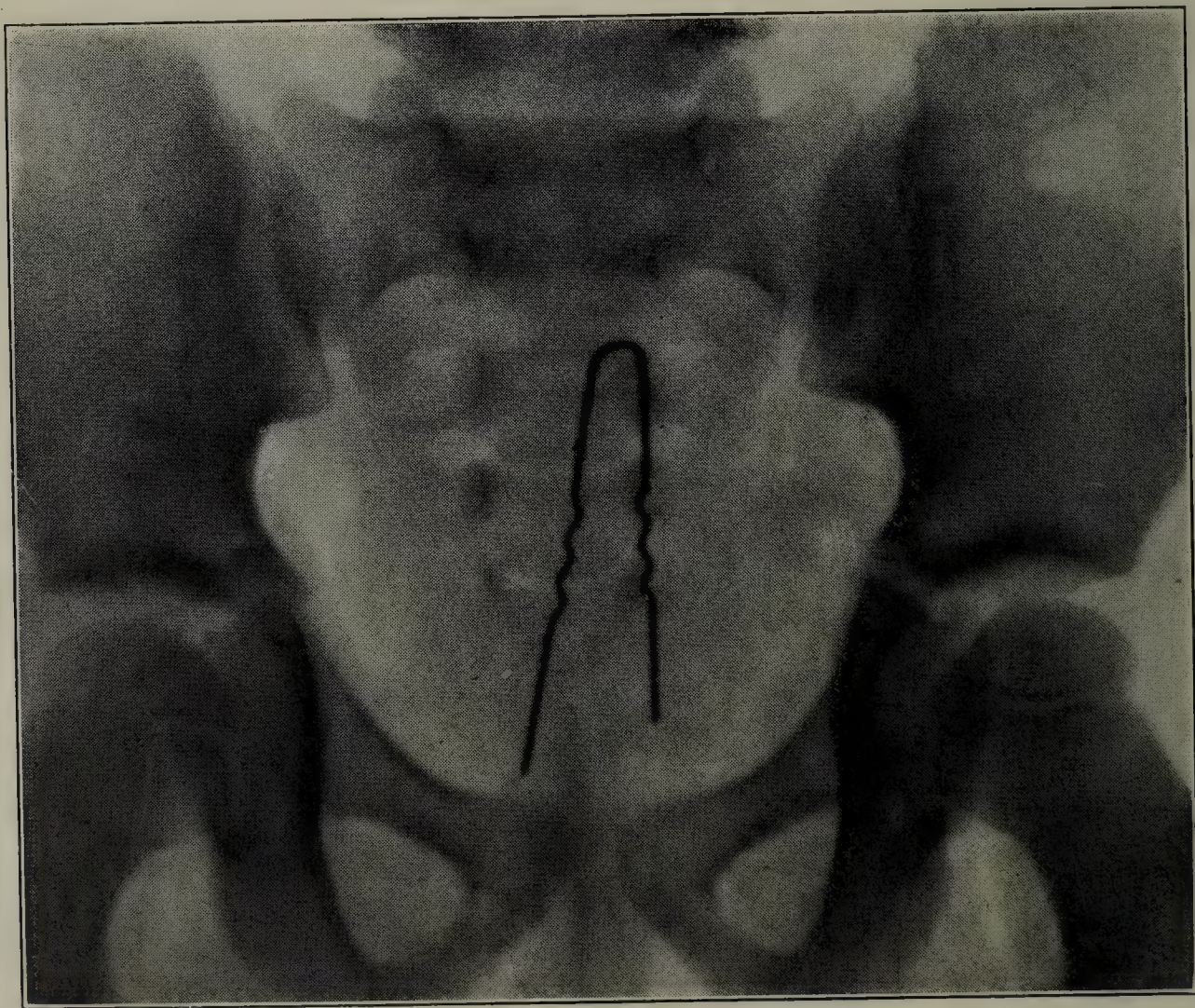


FIG. 113.—FOREIGN BODY IN THE BLADDER.

Clara R. (H.L.H. 75172) was brought to the hospital at the age of six years because of incontinence of urine, dysuria and occasional hematuria. These symptoms had been marked for more than a year. The urine was heavily infected. An x-ray (illustrated above) showed a hairpin in the bladder which the patient admitted having introduced *per urethram*. This was removed by the suprapubic route, the patient making an uneventful recovery.



## SECTION XIV

### DISEASES OF THE SKIN

**Incidence.**—The number of diseases which can properly be classified as diseases of the skin is steadily diminishing. One after another pathological condition, once thought to be confined to the skin, has been shown to be merely a cutaneous manifestation of some general process—an infection with metastatic skin lesions, a toxic or an allergic state. The incidence of skin diseases varies in different localities. In the tropics, for example, parasitic and insect-borne diseases are more common. The accompanying table gives the frequency with which various skin diseases have been met with in the Harriet Lane Home in Baltimore.

TABLE XLV

INCIDENCE OF SKIN DISEASES\* AMONG 74,000 ADMISSIONS TO THE HARRIET LANE HOME

Disease	Number of Cases	Disease	Number of Cases
Acne vulgaris .....	25	Ichthyosis .....	32
Acrodynia .....	11	Impetigo contagiosa .....	1561
Albinism .....	4	Insect bites .....	63
Alopecia areata .....	30	Irritative dermatitis (including mili- aria, intertrigo, diaper rash, etc.) .	778 †
Angioneurotic edema .....	55	Keloid .....	14
Burns, thermal .....	188	Leukoderma .....	26
Burns, chemical .....	9	Lichen pilaris .....	6
Burns, x-ray and radium .....	1	Lichen planus .....	5
Dermatitis exfoliativa .....	9	Lymphangioma .....	8
Dermatitis herpetiformis .....	8	Lymphedema, congenital .....	5
Dermatitis, infectious (pyoderma, furunculosis) .....	1162	Molluscum contagiosum .....	8
Dermatitis medicamentosa .....	15	Naevus (pigmented) .....	16 ‡
Dermatitis venenata .....	124	Pediculosis capitis .....	568
Ectodermal defects .....	3	Pediculosis corporis .....	6
Eczema .....	2960	Pityriasis rosea .....	13
Epidermolysis bullosa .....	1	Psoriasis .....	39
Erythema multiforme .....	30	Ringworm .....	410
Erythema nodosum .....	25	Scabies .....	1430
Erysipelas .....	137	Sclerema .....	24
Erysipeloid .....	2	Scleroderma, diffuse .....	7
Erythromelalgia .....	3	Scleroderma (morphea) .....	1
Granuloma annulare .....	5	Seborrhea .....	203
Granuloma inguinale .....	1	Telangiectases (multiple) .....	5
Hemangioma .....	208	Urticaria .....	517
Herpes simplex .....	44	Urticaria pigmentosa .....	2
Herpes zoster .....	58	Warts .....	19
Hydroa estivale .....	2	Xeroderma pigmentosum .....	1

\* The eruptive fevers, tuberculids, syphilids, purpuras and traumatic lesions are not included.

† These lesions are far more frequent than the figure given would indicate. In most instances such lesions were not entered on the diagnosis file.

‡ Large ones only.



## CHAPTER XC

## CONGENITAL LESIONS OF THE SKIN

## ICHTHYOSIS

Congenital, or more properly fetal, ichthyosis in its severe form is a rare disease characterized by the formation, usually all over the body, of a thick horny epidermis resembling parchment. This is divided by fissures or shallow furrows into irregular patches, sometimes two or three inches wide, at other times very small. In its milder form it is not uncommon. The disease begins in the early months of fetal life and is due to an abnormality of epidermal cornification. Sometimes it is familial.

In the gravest form of the disease the child is born dead with extreme deformities of the skin and external mucous membranes. This is the so-called



FIG. 114.—CONGENITAL ICHTHYOSIS IN PATIENT SIX WEEKS OLD.

“Harlequin fetus.” In other instances the child may live for a few hours, rarely more than a week. The openings of the nostrils and the ears may be occluded by the excessive production of epithelial cells. The eyes are in a condition of ectropion, and there are often deformities of the mouth and other orifices due to the contractions of the skin. The nails and hair are usually imperfectly developed. The body seems encased in a hard, horny covering, and looks as if it had been varnished or covered with collodion. The skin cracks or splits and the edges curl up, an appearance which has been aptly compared to the skin of a boiled potato.

In the milder form, the duration of life is indefinite, depending upon the degree of development of the disease; but even in such cases there may be seen the deformities at the orifices of the body, and there may also be a continued exfoliation of the epidermis in irregular patches. After this has separated, the skin beneath appears red and moist, but gradu-

ally becomes dry, hard, and shining, slowly contracting until it splits in various directions. Almost the entire body, or only certain areas may be affected.

The outlook for recovery is hopeless; in most of the severe forms death occurs in infancy, but in milder ones, life may be prolonged indefinitely. The “alligator boy” of the side show is an example of this class. The depth of the fissures seems



to determine the fatal outcome. If these are sufficiently deep infection is inevitable and it is this to which the patient succumbs.

The indications are to keep the skin moist and soft by the use of oils or ointments, and to prevent infection by perfect cleanliness. Although a certain amount of improvement usually follows these measures, a cure is not to be expected.

### ECTODERMAL DEFECTS

In the section on the teeth mention has been made of a group of unfortunate children who fail to produce certain of the ectodermal structures, notably hair, teeth, nails, and sweat and sebaceous glands. These individuals are not usually either completely bald or edentate, but they develop few teeth and a very small amount of coarse hair. The hair which may appear is confined to or is thickest at the sides of the head, the top of the calvarium being nearly or quite bald. The hair emerges from the smooth shining skin at a very acute angle. The permanent denture is not formed and the few milk teeth which occur are usually cone-shaped. Apart from the deformity these individuals suffer most acutely from absence of sweat glands and bear hot weather badly. They may, if the sweat glands are completely absent, suffer heat stroke and syncope on exposure to the summer sun unless the skin can be kept wet by wetting their clothing.

Nothing can be done for these children except to supply them with artificial dentures. There is always a tendency toward differentiation of new hair follicles and sweat glands but they cannot be expected to attain a normal hirsute covering.

### SKIN DEFECTS

Quite a different matter from the ectodermal defects are the so-called skin defects of the newly born. These defects are represented by areas several centimeters in diameter, from which the skin appears to have been torn away and replaced by an angry red scar, which merges by a gradual transition with normal skin at the irregular borders of the lesion. The lesions are usually found over one of the parietal bones, but may occur in any part of the body. They involve the entire skin down to the cutis vera. The importance of the recognition of their significance lies in the fact that they may be mistaken for the result of obstetrical trauma. Excision of the scar and skin grafting offer the only cure of the disease.

### ALBINISM

Albinism, which is usually complete, is the name applied to the condition of absence of pigment from the skin, hair, and choroid. It is often familial and may be accompanied by mental defect. Nystagmus and photophobia are consistently present.

The condition is incurable, but relief of the ocular symptoms may be afforded by tinted glasses.

### IDIOPATHIC EDEMA

Localized edema, usually affecting one or more extremities, may be present from birth on, or may appear at any time during childhood. These conditions usually persist throughout life. In some instances the condition is hereditary



(Milroy's disease); in others no family history can be obtained. Even in the hereditary cases edema sometimes develops only toward the end of the first decade. The cause of the edema is not clear; it has been attributed to an anomaly of the lymphatics or veins, and has also been regarded as a trophic disturbance. Still mentions instances in which the edematous limb outgrew its fellow. Attacks of pain with swelling and redness have been described in some cases of Milroy's disease.

In milder cases no treatment may be needed; for the more severe ones bandaging the limb or an elastic stocking may make the patient more comfortable.

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## CHAPTER XCI

### DISEASES OF THE SKIN DUE TO PHYSICAL AND CHEMICAL AGENTS

#### IRRITATIVE DERMATITIS

**Miliaria (Prickly Heat).**—This condition is common in warm weather. It is an inflammation about the sweat glands. Sometimes their ducts are obstructed and tiny vesicles appear on top of the red papules. The eruption may itch and be scratched, resulting in secondary infection. It is an essentially benign condition, and is to be treated by lighter clothing, frequent bathing and either a dry dusting powder or, if there is much itching, with calamine lotion.

**Intertrigo.**—This term is rather indiscriminately applied to any eruption which develops upon two moist surfaces which are in contact. There may be a simple erythema or a dermatitis resulting from traumatism or the decomposition of secretions. Intertrigo is seen in the folds of the groin, between the scrotum and the thighs, between the buttocks, about the anus, in the axillae, on the neck, or behind the ears. Its essential causes are moisture, friction, want of cleanliness, and sometimes infection. There is an intense uniform redness, and in some cases the epidermis is denuded over large areas, and the surface is moist. There is no thick crusting and little or no itching. It is common in very obese infants.

The disease is generally seen in its worst form about the buttocks, perineum, external genitalia and thighs. This is the familiar *diaper rash* or *ammoniacal dermatitis*. Not infrequently the whole skin surface covered by the diaper is inflamed, and may be excoriated; in cases of long standing the condition may become eczematous. In boys the urethral meatus often is the seat of an annular ulceration, the secretions from which may completely obstruct the opening with a firm dry crust; under these conditions there is dysuria, the diaper may be flecked with blood, and leukocytes and red cells appear in the urine.

In a few cases the trouble is caused by the use of an excessively alkaline laundry soap, with inadequate rinsing of the diapers. In the majority, however, it depends on bacterial decomposition of the urine, with the production of ammonia from urea.

Intertrigo is seldom difficult to control. Dry treatment with frequent application of a dusting powder is all that is required for the lesions other than in the diaper area. For the latter it is desirable to leave the child exposed to the air with a diaper beneath him instead of pinned on him. Exposure to the sunlight or a sun lamp is helpful in obstinate cases. With a little watching soiling can easily be prevented. Some mild ointment like zinc oxide ointment should be applied at night when it is not practical to dispense entirely with the napkin. Often a diminution in the total fluid intake is of assistance. The action of bacteria may be checked



by using a saturated solution of boric acid or a 1:5000 solution of mercury bichloride as the final rinsing water in washing the diapers; a small amount of the chemical remains in them when they are dried and limits, though it does not entirely prevent, bacterial decomposition. The condition is often aggravated by the use of rubber protection over the diaper when the child is taken out; this saves external appearances at the expense of his comfort.

## BURNS

Children are peculiarly subject to misadventures of all kinds—burns among them. Hot liquids are the most common agents, but chemical and electrical burns are not unusual. The local treatment of these injuries is largely within the province of the surgeon, but the medical treatment is of equal importance, particularly in children, in whom dehydration constitutes a more serious problem.

The clinical picture of a severe burn is characteristic. Signs of shock appear shortly after the injury—prostration, pallor, a subnormal temperature, low blood pressure and a rapid, thready pulse. These symptoms usually clear up within twelve hours and the patient's general condition appears good. However, within twenty-four to forty-eight hours of the original injury toxic manifestations develop. The temperature rises as does the pulse rate. There is a leukocytosis. Marked prostration develops and there may be cyanosis and perhaps vomiting. The condition becomes progressively worse and may terminate fatally in coma. When recovery takes place the patient continues to show septic manifestations for days or weeks. Gradually as the condition of the wound improves these tend to disappear.

The medical treatment of burns during the early stage of shock consists in maintaining the body temperature, in giving stimulants such as epinephrine and caffeine, and in administering fluids. Primary shock is rarely a serious problem; the real difficulty lies in controlling the toxemia which develops later. There has been much discussion as to the cause of this toxemia. It has usually been attributed to a toxin of unknown nature formed by the burning of tissue. This view has recently been seriously questioned, and it now appears that the two important factors causing the toxemia of burns are dehydration and bacterial infection. The factor of dehydration has been studied extensively by Underhill and his collaborators. The quantity of fluid lost in the oozing secretions and sidetracked as edema may be very great indeed, often sufficient to impair renal function. Pathological observations bear eloquent witness to the part played by bacterial infection. In fatal cases sections of the wound invariably show myriads of organisms. Beyond a doubt dehydration exaggerates the bacterial toxemia.

Vigorous treatment of dehydration is indicated in all burn cases. Fluids, particularly normal saline, should be given, parenterally if necessary, until a generous flow of urine is secured. The factor of infection can be prevented more readily than cured. The local treatment is of great importance here. If the burn is seen within the first few hours, unruptured blisters need not be broken; instead they may be injected with a 1 per cent solution of gentian violet. This prevents infection very effectively, as Firor has shown. If some time has elapsed, it is advisable to clean up the entire area thoroughly; blisters, loose epithelium and dead tis-



sue should be removed. It is preferable to err on the side of radicalism here. The wound is then washed with an antiseptic like ether which also removes oils which may have been applied. In fresh burns this *débridement* may be painful and should be performed under anesthesia. When the wound has been cleaned the entire area is sprayed with 1 per cent gentian violet or 2.5 per cent tannic acid solution. Both are satisfactory dressings, the former being more of an antiseptic but less of a coagulating agent than the latter. The patient is then placed in bed; the burned parts are exposed to the air constantly and sprayed with antiseptic solution at intervals of one or two hours until a firm coagulum has formed. The formation of a dense crust serves as a great deterrent to infection and permits healing to take place beneath. However, this is not always successful, and one must be constantly on the lookout for evidence of suppuration beneath a crust. Should this occur the crust should be softened with hot applications until it falls away, and, after a new *débridement*, antiseptic spraying may be recommenced.

The indications for skin grafting follow general surgical principles. Transfusions may be useful in combating toxemia and in providing fluid. We question very much if exsanguination transfusions have any further value. We have seen this treatment tried several times and it has not been followed by striking results.

The prognosis in burns usually depends upon the size of the area affected. The old rule that recovery does not occur when more than one-third of the body surface has been burned is, however, no longer infallible. Adequate treatment of dehydration has improved the results, and it is now not so very rare to see recovery when almost one-half of the body has been burned.

### SUNBURN

Severe cases of sunburn (erythema solare) are unusual, but are becoming more frequent of late years as a result of the enthusiasm that has developed for sun baths and other forms of ultraviolet ray therapy. It must be remembered that while the rays of the sun and the mercury quartz arc are beneficial up to a certain point they may become dangerous in excessive doses, and death has been known to occur from overexposure to the mercury lamp. There are some individuals who are sensitive to rays of short wave length; frequently children are met with who fail to tan but burn again and again.

In the ordinary mild burn the inflammatory reaction is not extensive, but in extreme cases there may be all the appearances of a second degree burn, and if a large surface of the body has been burned the possibilities of infection and dehydration are equally serious. There may be high fever and prostration.

The treatment for severe sunburn is the same as that described for other burns. Untoward experiences of this kind can readily be prevented by a more cautious and more gradual exposure to ultraviolet light.

### HYDROA AESTIVALE

This exceedingly rare but interesting disease manifests itself by a vesicular eruption which has a seasonal incidence in the summer and is evidently, in part at least, the result of exposure to sunlight.

The malady usually makes its appearance during the early summer of the third



or fourth year of life and disappears in the autumn; it recurs in each succeeding summer—frequently until the age of puberty, after which it is very rare. The eruption occurs on exposed areas (face, hands, arms and, when the child is in the habit of running barefoot, on the legs and feet). If thin clothing is worn the lesion may have a wider distribution.

The lesion consists of discrete or confluent vesicles, many of which may be umbilicated like a pustule of smallpox. They appear on an erythematous background, eventually dry up, and form crusts which fall off, leaving scars. Hematoporphyrin is found in the urine of some of these patients. This is a substance of known photosensitivity, and is regarded as playing an important part in the production of the lesions.

The patient should be protected from the sun. Calamine lotion is of value in the early stages of the eruption, and zinc ointment when crust formation has taken place. Fowler's solution internally has been recommended.

### **XERODERMA PIGMENTOSUM**

This is an unusual disease, supposedly congenital, but it is certain that light plays a predominant rôle in activating the condition. The course is marked by seasonal remissions during the cold months and exacerbations in the summer. Early in life, usually before the third year, freckle-like areas of pigmentation appear on exposed surfaces, notably the face. After a season or two these no longer fade in winter. Then telangiectases, hyperkeratoses and ulcers develop and eventually the condition becomes one of fungating carcinomatosis of the affected areas.

Early in the disease the exposed skin may be smeared with a brown ointment to protect from light. Roentgen rays should not be used, as they aggravate the condition.

### **EPIDERMOLYSIS BULLOSA**

This disease is due to a congenital anomaly of the skin, as a result of which bullae may appear on any part of the body from the slightest trauma. The blebs develop rapidly and are of varying size from 0.5 to 6 or 7 centimeters in diameter. They usually contain yellowish serum, but the exudate may be hemorrhagic and may become secondarily infected. The blisters rupture rapidly and expose a slightly inflamed area beneath. They are most numerous over the legs, ankles, feet, wrists and abdomen, but any part of the body may be involved. The finger and toe nails are sometimes atrophic in these patients.

The disease persists in many cases into adult life, although there may be remission or even disappearance of the condition about the time of puberty.

Medication is ineffective. The only thing which can be done for these patients is to protect the skin from trauma as adequately as possible.

### **DERMATITIS VENENATA**

Dermatitis venenata is a nonspecific term and includes lesions produced by contact with a variety of organic and inorganic substances, among which may be mentioned oleoresins from poison ivy, poison oak, sumach and primrose, various



pollen oils, certain Chinese lacquers, salts of nickel and some other heavy metals. By far the commonest cause in the eastern part of the United States is contact with the plant *Rhus toxicodendron* (poison ivy), while in the western states *Rhus*



FIG. 115.—EPIDERMOLYSIS BULLOSA IN A GIRL ONE YEAR OLD.

*diversiloba* (poison oak) is the chief offender; in dermatitis produced by either of these agents the clinical picture is virtually identical. The ensuing discussion will be limited to *Rhus* dermatitis.

Susceptibility to these plants is found in about 70 per cent of white persons; all



degrees of sensitiveness are seen. Some individuals require intimate contact with the leaves or stem, whereas others are so sensitive that they are poisoned if they pass near a fire where the plant is being burned. It has been shown that susceptibility to the toxic lipoid depends on previous contact with it; this contact need not be intimate, but may be obtained by transfer of minute quantities through the air. Eskimos, in whose environment the plant is not found, react negatively to it. The same is true of young children; according to Coca, children under three years of age are not usually susceptible, but can be made so by sufficient contact. Immunity to the poison may be capricious; there are instances of individuals who have been able to handle the plant for years without being poisoned, who suddenly lose their immunity and develop extremely severe lesions. There is no relation between atopic hypersensitiveness and susceptibility to poison ivy.

The lesions appear in twenty-four to forty-eight hours after contact. Pruritus is first noted, then there develops a small red papule, which on close inspection is found to have a thick-walled vesicle in the center. The lesions occur in clusters. In individuals who are only moderately susceptible larger lesions do not develop, but the poison may be spread to any part of the body by scratching and secondary lesions may continue to develop for weeks. In highly susceptible individuals the vesicular nature of the eruption is apparent almost at the start. Large blebs may form. There is erythema and edema of the surrounding skin.

Dermatitis venenata is a very annoying disease and may have serious complications. There are the usual possibilities of secondary infection from scratching, but the greatest danger is from carrying the poison to the eye. Two such cases were recently seen at the Johns Hopkins Hospital which developed perforating ulcers of the cornea. The greatest care should be taken to prevent such accidents in children.

Oxidizing agents are said to destroy the poison, and painting the skin with potassium permanganate 1:1000 appears to be an effective prophylactic in cases of known exposure. Once the disease has become established, its course is not greatly influenced by local measures; treatment is largely symptomatic. The involved areas should be thoroughly cleansed with soap and water, and alcohol or potassium permanganate applied to remove or destroy any of the poison remaining on the surface. Antipruritic lotions such as calamine lotion may then be applied or kept in contact by means of compresses. Good results have been reported from the use of 12 per cent benzyl alcohol ointment. It has not been our personal experience that the course of the dermatitis was appreciably shortened by opening the blisters and applying permanganate. After crusts have formed, the application of any bland ointment will facilitate desquamation.

Specific treatment by means of an alcoholic extract of the plant injected intramuscularly is effective in diminishing susceptibility to the poison. It is also of some therapeutic value.

### DERMATITIS MEDICAMENTOSA

For details of the types of eruption that can be produced by various drugs the reader is referred to works on dermatology and toxicology. The conditions the physician is likely to meet with will be influenced to a considerable extent by the



drugs he is in the habit of using himself. From our records, bromides, phenobarbital (luminal), and sulphur have been the most frequent offenders. However, only 6 instances of luminal rash were observed in the Harriet Lane Home, even though this drug has been in common use for more than twelve years. Bromide eruptions can readily be prevented if the bromide concentration of the blood serum is followed. Diethelm has shown that the blood bromide rises some time before untoward symptoms appear.

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## CHAPTER XCII

### INFECTIONS OF THE SKIN

#### FURUNCULOSIS

Pyogenic infections of the skin are exceedingly common in infants, especially in those who are debilitated. This group includes anything from the minute hair follicle infections to large furuncles, which may appear all over the body.

These infections are nearly all due to staphylococci, but streptococci may be responsible. Want of cleanliness is often a predisposing factor at the start, but when the organisms gain a foothold they may be very difficult to eradicate. Sometimes boil after boil appears—most often on the scalp, face and shoulders, but the entire body may be covered. They may continue to develop in crops for months.

Treatment should be directed toward the general nutrition. Some obstinate cases are benefited by the prolonged administration of yeast; dried brewer's yeast may be given in half-teaspoonful doses two or three times a day, or one-quarter to one-half of an ordinary yeast cake may be taken. Local treatment should have for its first object thorough cleanliness of the skin. This is best secured by frequently bathing the parts affected with alcohol. In our experience the best plan for treating the multiple small furuncles is to delay incision until they have pointed. For general furunculosis or the continual recurrence of larger abscesses the use of staphylococcus vaccines is indicated. While autogenous vaccines are perhaps preferable, the use of stock vaccines seems in most cases to be equally effective. Injections should be repeated every four or five days; beginning with fifty millions, the dose may be increased to one hundred millions, or even more. The beneficial effects in many cases are striking and the cure permanent; others seem to be little influenced by this treatment. Daily exposure to sunlight or an ultraviolet lamp seems to be effective in some instances. These infections have a marked tendency to recur; the general hygienic treatment must in any case be continued for months. Overdressing should be avoided, since it favors new follicular infections.

#### IMPETIGO CONTAGIOSA

Impetigo contagiosa is a disease caused by streptococci or staphylococci and characterized by the formation of discrete vesiculopustules, occurring most frequently upon the hands and face. Cases are usually seen in groups affecting children in one family or institution. Impetigo may be communicated from one person to another, or may have its origin in some chronic infection, especially in the nose and ears. It is easily spread by auto-inoculation from one part of the body to another. It is a highly contagious affection. In institutions it is often very difficult to control, and the most rigid precautions are required to prevent epidemics.

The earliest lesions are vesicles, from pinhead to pea-size, which rapidly en-



large; they are clear at first, but later the contents become turbid and slightly yellowish. They are usually flaccid rather than distended. Subsequently they rupture and dry, forming thick yellow crusts, which have the appearance of being stuck on, the surrounding skin being quite healthy. After the crusts fall off, a small red patch remains, which slowly fades. The true skin is not usually involved, except in poorly nourished, cachectic subjects or as a result of scratching. Under such circumstances ulceration may occur. The small vesiculopustular lesions described may enlarge to form bullae one to two inches in diameter, filled first with serum, afterward with thin pus. Very little inflammation is seen about these patches, and in most cases the intervening skin is normal. Large lesions are especially likely to occur in the newly born, in whom the disease is often termed *pemphigus neonatorum*.

The favorite site of the eruption is the face, but it may appear on any part of the body. There may be only half a dozen vesiculopustular lesions or from thirty to forty may be present. The smaller ones sometimes coalesce and form lesions of considerable size. Itching is never a prominent symptom.

Impetigo, if promptly treated, may clear up in a few days, but often it lasts for weeks and, by continued auto-inoculation, may persist much longer than this.

The diagnosis is seldom difficult. The characteristic features of the disease are the appearance and distribution of the lesions, the absence of a surrounding areola, the almost complete absence of itching, and the occurrence of several cases together. The diseases most likely to be mistaken for impetigo are varicella, a pustular syphilitic eruption, and epidermolysis bullosa.

Treatment is simple and usually very effective. The crusts are to be softened and removed by thoroughly washing the part with soap and water. Gentian violet (1 per cent aqueous solution) or ammoniated mercury ointment (3 per cent) may then be applied.

### DERMATITIS EXFOLIATIVA

This condition is characterized by large confluent areas of erythema with desquamation of the skin in paper-like flakes. It usually involves the greater part of the body. If the process reaches the hair and nails these may be shed; it may affect the conjunctiva.

Dermatitis exfoliativa is a symptom complex rather than a disease entity. In the newly born it is known as Ritter's disease, and is seen during the course of epidemics of impetigo, being apparently a manifestation of the same infection. These cases are accompanied by high fever and constitutional symptoms, and the mortality is high. In older children dermatitis exfoliativa is rarely seen. It occurs as one of the less frequent manifestations of arsphenamine poisoning. It is a chronic condition, often lasting for months. There is no specific treatment; the skin should be cared for in the same manner as in any generalized dermatitis.

### ACNE VULGARIS

Acne is a disease of early adolescence, but is occasionally seen during the latter part of the first decade. It consists in an inflammation of the hair follicles and sebaceous glands with the production of papular and pustular lesions intermingled



with comedones. Seborrhea is usually present. Acne has a special predilection for the face, but may involve the shoulders and back.

The condition appears to be caused by the action of certain fat saprophytes (acne bacilli, staphylococci, Unna's bottle bacillus) combined with some constitutional abnormality affecting the character of the sebaceous secretion.

The treatment consists in general hygienic measures and regulation of the diet, which should be low in carbohydrate. Constipation should be avoided. Locally, applications of sulphur ointment or of zinc sulphate lotions have been recommended. Probably the most effective local treatment is cautious use of the x-ray to check the activity of the sebaceous glands. Other parts of the face must be carefully protected.

### DERMATITIS HERPETIFORMIS

This is a rare disease characterized by vesicular, bullous and erythematous lesions which may be painful or itch intensely. It is relapsing and extremely refractory to treatment.

Microscopic examination of sections from the affected skin shows an infiltration of the papillae with cells, many of which are eosinophils. The fluid in the blisters contains these cells in large numbers and they are also increased in the circulating blood.

The eruption, which may be preceded by intense itching, is at first erythematous. It may extend over the entire body, but the extremities are particularly affected. In the center of these erythematous areas vesicles usually appear, and the eruption is generally in the vesicular stage when the patient is first seen. The vesicles vary from pinhead-size to a centimeter or more in diameter. The fluid is clear at first, but rapidly becomes cloudy. Eventually the affected bullae dry up, the erythema subsides and the lesions clear away, only to be followed by a new crop. The disease has a tendency to remit and recur, and recurrences may come on after years. Among children the nutrition may suffer severely.

Arsenic in the form of Fowler's solution seems the most useful therapeutic agent. Arsphenamine has also been employed. Sulphur baths are recommended.

### MOLLUSCUM CONTAGIOSUM

These small wart-like growths are caused by a filtrable virus. They are rounded, smooth nodules, often with a constricted pedicle, which have in their centers a shallow depression which appears to be covered with a tiny crust or filled with a plug of dark brownish material.

The microscope shows the plug to consist of degenerated epithelium and the epidermal cells show large characteristic oval inclusion bodies. The disease is only slightly infectious.

The tumors may be removed surgically or destroyed by electrodesiccation; they may disappear after being touched with pure carbolic acid followed by alcohol.



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## CHAPTER XCIII

### DISEASES OF THE SKIN DUE TO PARASITES

#### PEDICULOSIS

*Pediculosis capitis* is common in hospital and dispensary practice; other forms of pediculosis are exceedingly rare in children. The characteristic nits are seen as small, white ovoid bodies attached to the hair. These are the eggs of the louse. The parasites themselves are difficult to find unless they are present in large numbers. Nits can be distinguished from dandruff by their smooth regular appearance and uniform size, and by their firm adherence to the hair.

Treatment must be directed both toward the parasites and toward the eggs. The child's head should be wrapped in a towel moistened with tincture of delphinium or with equal parts of kerosene and olive oil; this should be left on overnight. The following morning, the hair is washed with soap and hot water. The nits may be removed by first soaking the hair in warm vinegar, which serves to loosen them so that they may be combed out or wiped off with gauze. In cases of heavy infestation and in institutions the problem is greatly simplified by cutting the child's hair short. Cleanliness is necessary to prevent recurrence.

#### INSECT BITES

Various insects produce their characteristic lesions. In most instances the subject is quite familiar with the source of the lesion. Occasionally, however, some doubt arises as to whether or not lesions are due to insect bites. The localization of lesions is helpful; mosquitoes, for example, can penetrate clothing only to a limited extent and produce lesions in more exposed regions, whereas fleas, bedbugs and other crawling insects rarely bite in exposed portions, and there is likely to be a group of lesions close together. A careful inspection of the lesions will usually reveal the central wound made by the insect.

#### SCABIES

Scabies is a contagious disease due to the burrowing into the skin of the female itch mite, *acarus scabei*, with secondary lesions which result from scratching.

The burrowing of the acarus is usually where the skin is moist and thin—between the fingers, on the flexor surface of the wrists, the axillae, and, in males, the genitals. It is not seen upon the face, except in infancy, when infection may occur from contact with the breast of the mother. The primary lesion is a characteristic black-dotted line 0.5 to 1 centimeter or more in length, called a "burrow," caused by the crawling of the female parasite under the horny layer of the skin for the purpose of laying eggs. The black dots are formed by the feces of the parasite. These burrows are often difficult to find, for small, inflamed papules



and vesicles develop at these sites. The classical localization of the lesions along the ulnar border of the hand and between the fingers has in our experience been unusual in children. The intensity of the inflammatory lesions varies greatly in different cases; in some they are very few, while in others, particularly in delicate, cachectic, and neglected children, they are sometimes very severe, so that the skin of the affected part is nearly covered with pustules. The secondary lesions are due to infection by streptococci or staphylococci. A pustular eruption upon the hands should always suggest scabies. The lesions which result from scratching may be found on any accessible portion of the body. Impetigo is a common complication.

The diagnosis of scabies is usually quite easy, as several children in a family are likely to be affected, particularly if they occupy the same bed. The diagnostic features of the eruption are the presence of papules, vesicles, or pustules, especially upon the hands, wrists, and genitals; the small size of the lesions and the extreme pruritus with evidences of scratching and secondary infection. Careful examination with a lens will at times disclose some of the characteristic burrows. In young subjects scabies can be easily confounded with lichen urticatus, sometimes with dermatitis venenata.

Scabies may always be cured, provided sufficient precautions are taken to prevent reinfection. This necessitates boiling or baking, not only the patient's clothes, but all the bedding as well.

Treatment should commence with a hot bath, in order to soften the epithelial scales about the burrows. The body should be thoroughly scrubbed with soap and water, preferably with a nail-brush, the bath being continued for at least half an hour. It is well to do this at night. After the bath, the body is anointed with the parasiticide, which should be thoroughly rubbed into the skin, clean clothing applied, and the child put into a perfectly clean bed. In the morning the ointment may be washed off, but none of the clothing previously worn should be put on. This treatment is to be repeated on two or three successive nights, and if thoroughly done it will effect a cure. The ordinary sulphur ointment is too irritating for use in small children, and it is advisable to use one-third of the usual U.S.P. strength. After the use of the parasiticide there is generally required, for a few days, some soothing application. One should always try to ascertain whether other members of the same household are infected and see that they are treated simultaneously; otherwise the results are apt to be discouraging.

## RINGWORM

Ringworm is a fungus affection that may involve either the scalp (*tinea tonsurans*) or the skin elsewhere (*tinea circinata*). Occasionally it affects the nails (*tinea unguium*) and feet (*dermatophytosis*). Various species of fungus are concerned in the production of these lesions.

**Ringworm of the Scalp.**—This is a very frequent disease in institutions for children, often occurring as an epidemic. The primary lesion usually consists in a red papule surrounding a hair; this gradually increases in size until it is from one to two inches in diameter, but rarely larger than this. Sometimes several of the patches coalesce. The affected areas always have rounded borders and are sharply



outlined. The hairs are lacking in luster, are very brittle, and often broken off close to the scalp, so that the area may appear to be bald. The stumps of the broken hairs point in all directions. The fungi penetrate the shaft of the hair; both the spores and the mycelium may be seen under the microscope. The spores are present in great numbers in the hair, but the mycelium is most abundant in the scales. The amount of inflammation found in diseased areas varies much in the different cases. There may be only a scaliness of the scalp, or a formation of pustules in the hair follicles, the hairs loosening and falling out in consequence. In young infants, where the hair is scanty and thin, the disease resembles *tinea circinata*—*i.e.*, it is superficial, and the hair follicles are often not involved. Children of all ages are liable to *tinea tonsurans*. It flourishes particularly among children who are dirty and generally neglected.

The diagnostic feature of the disease is the presence of scaly patches, with loss of hair; the patches are usually circular, and by examination with a lens the stumps of broken hairs are seen all over the diseased areas. By microscopic examination the fungus may be discovered. In typical cases the diagnosis is easy if the process is at all advanced, but there are many atypical forms and many mild cases where the recognition of the disease is difficult. The symptoms are often masked by the inflammatory conditions present. The disease may be confounded with seborrhea; but in the latter the lesion is diffuse, never sharply defined; there is general thinning of the hair over the scalp, and never the stumpy broken hairs. Psoriasis has points of resemblance; but it is usually found on other parts of the body, especially the knees and elbows, and upon the scalp the patches are more numerous and smaller. In eczema the loss of hair in circumscribed patches is never seen, nor are the broken stumps. In alopecia areata the patches are never inflamed or scaly; the stumps of hairs remaining in the bald patches are of the "exclamation point" type, the hair being thinned out and eroded toward the root.

*Tinea tonsurans* is always curable, provided the patient can be kept under close surveillance, and treatment thoroughly carried out, but it is particularly obstinate. There is no tendency to spontaneous recovery except toward puberty, when many of the cases recover even without treatment. In a recent case, treatment must usually be continued for several weeks or months, and in chronic cases from six months to one year with the closest supervision.

Treatment with parasiticide ointments, such as 10 per cent sulphur, is not very satisfactory but, if persisted in long enough, may cure. The lesions should be scrubbed daily with soap and hot water before the salve is applied. The repeated daily application of tincture of iodine is sometimes effective. Pulling out the affected hairs with forceps will also help. The most satisfactory results are obtained by epilating the affected areas with x-ray, but great care must be exercised or permanent baldness may result.

**Ringworm of the Body.**—This may or may not be associated with *tinea tonsurans*. In some instances the infection is apparently acquired from cats and dogs.

The characteristic lesion is usually a circinate erythema, with moderate scaling and fine vesicle formation around the edges. The diagnosis can be made with certainty only by microscopic examination of a bit of scale soaked in potassium



hydrate solution; this reveals the mycelial threads. The most effective treatment is the local application of Whitfield's ointment.<sup>1</sup>

When ringworm lesions occur between the toes, the characteristic scale is not seen. Instead the epithelium, moistened by perspiration, comes off in larger masses, leaving a raw surface beneath. Such lesions between the toes are the familiar "athlete's foot." The infection may be latent and flare up only in warm weather when there is free perspiration. School children commonly acquire these infections from gymnasiums, swimming pools, etc. The local treatment is the same as for other forms of tinea circinata—Whitfield's ointment. Osborne has reported excellent results in preventing such infection in public school gymnasiums by a prophylactic foot bath with hypochlorite solution.

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	<i>Gms. or C.C.</i>
<sup>1</sup> Salicylic acid .....	65
Benzoic acid .....	65
Coconut oil .....	2
Petrolatum .....	15



## CHAPTER XCIV

### NEOPLASMS OF THE SKIN

#### HEMANGIOMATA

The vascular nevi are congenital anomalies, the common varieties being (1) the raised type (strawberry marks), (2) capillary hemangiomata (port-wine stains) and (3) cavernous angiomata, which are largely below the surface of the skin.

The first two types are more often seen about the face, and vary in size from a pinhead to several centimeters in diameter. The strawberry marks are elevated, with a smooth, irregular, and in some cases verrucose surface. The port-wine stains are perfectly flat, and there is no change in the skin except the red color. This deepens on crying or coughing and disappears on pressure. The mucous membranes as well as the skin may be involved in the tumor. The cavernous angiomata are usually more deeply situated; they are globular and lobulated, and contain large blood vessels. They may be bluish or have a normal skin color.

Small, superficial nevi, particularly those of the port-wine variety, will occasionally involute and disappear entirely. Indeed, in the case of the hemangiomata so commonly seen in the occipital and nuchal regions in newly born infants this result may as a rule be confidently expected. With the strawberry marks and cavernous hemangiomata this is less likely to occur; sometimes these tumors grow tremendously with the growth of the child. They may at any time become wounded or infected, and in the former event give rise to serious hemorrhage. Hemangiomata involving the meninges or the brain sometimes occur in association with the cutaneous ones.

For the smaller strawberry marks carbon dioxide snow or electrodesiccation may be effective. Radium, however, is the most satisfactory treatment for the majority of cases. For the port-wine stains little can be done, but some spontaneous improvement may be expected. For the cavernous hemangiomata, surgery or electrodesiccation may be indicated.

#### PIGMENTED MOLES

Pigmented nevi may be present at birth or develop in extra-uterine life. They may be single or multiple and are found on the face, extremities or any part of the body. They are occasionally of enormous proportions as compared to the surface area of the child's body. We have seen a hairy mole which involved the entire trunk except the shoulders and gave the child the appearance of being wrapped in the skin of a beast. The depth of the pigmentation varies. The surface may be smooth or wart-like and the lesion is sharply circumscribed. Hair is usually present and may be sparse and downy or coarse and very abundant.

The ordinary small moles require no treatment unless they are disfiguring, or



in a location subject to trauma. They may be removed by electrodesiccation. With large moles there is more danger of their becoming malignant; they should be removed surgically and the denuded areas covered by skin grafts. Any mole which gives evidence of rapid growth should be excised without delay.

## WARTS

These are benign epithelial tumors involving all layers of the skin. They are most commonly found on the hands, but may be met with anywhere. Irritation certainly plays a part in their production, but it has been shown conclusively that they are produced by a filtrable virus and can be reproduced by inoculation of filtered material from a wart.

They may be unsightly, but are not troublesome except when they affect the sole of the foot; walking may then be painful.

Cauterization with concentrated nitric or trichloroacetic acid applied with a match is effective in most instances with small warts. It must be done with care. Carbon dioxide snow and electrodesiccation may also be employed. When the warts are large and numerous it may be advisable to x-ray them, protecting the surrounding skin with lead-foil.

Internal medication is sometimes followed by prompt disappearance of warts. Many drugs are recommended—arsenic and mercury preparations have most frequently been successful. However, warts are notoriously capricious and may disappear spontaneously, so that it is difficult to be certain of the efficacy of such remedies.

## KELOID

This is a dense fibrous tissue formation developing usually in the site of a scar. It is seen particularly in Negroes and has a tendency to develop in certain families. These tumors may reach enormous size, though they remain benign. Sometimes their growth is arrested and involution takes place.

Roentgen ray or radium, either alone or combined with surgery, is the best method of treatment.

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## CHAPTER XCV

### MISCELLANEOUS CONDITIONS

#### ERYTHEMA MULTIFORME

This is characterized by the appearance of multiple erythematous, vesicular or bullous lesions distributed symmetrically over the body. The lesions show a special predilection for the backs of the hands, the forearms, cheeks and sides of the neck and the legs. They are all inflammatory and exudative in character, but may show considerable variation in their appearance. Sometimes they are hemorrhagic. They are usually round but may be circinate. They usually appear simultaneously, last from a few days to several weeks, and fade gradually. There is a marked tendency to recurrence. The lesions often fade in the center, and with a recurrence one may find new lesions appearing in the faded central portions of the old. The mucous membranes may be affected. Itching is not a striking feature.

Erythema multiforme is frequently associated with fever, and occasionally with joint symptoms or abdominal cramps (*vide* anaphylactoid purpura). In all probability it is not a specific disease but a cutaneous manifestation that may accompany a number of different processes. Often enough there are no sequelae whatever, but its chief importance lies in the fact that not infrequently it is a manifestation of rheumatic fever. This possibility should always be kept in mind and other evidences of rheumatic infection carefully sought.

#### ERYTHEMA NODOSUM

This is a very definite clinical entity, characterized by a sudden onset with fever and constitutional symptoms and the appearance of red, painful, tender nodules on the extremities. Joint symptoms are sometimes present. The nodules are oval and are parallel to the extremity. Their site of predilection is on the anterior border of the shins, but they may also develop on the anterior surface of the thighs or the extensor surface of the arms. They develop rapidly, reaching their full size—1 to 2 centimeters in diameter—within twenty-four hours and subsiding in about a week. They sometimes appear in successive crops. The number is usually small—from 1 to 12 nodules in all. They are deeply seated, involving the subcutaneous tissue as well as the skin, but not underlying structures. The constitutional symptoms rarely last more than a week, after which no new nodules develop. Recurrences and second attacks are not described.

There has been much discussion regarding the nature and significance of this process. In some instances it is certainly associated with active tuberculosis; in others tuberculosis cannot be demonstrated. It is sometimes associated with definite rheumatic manifestations, and occasionally with other diseases. At times it appears when no other pathological process is demonstrable.



The experience with this condition in different localities differs widely. In Scandinavia and northern Europe it is apparently much more common than in this country and is nearly always associated with active tuberculosis. In this country erythema nodosum is comparatively rare and is less frequently associated with tuberculosis. Of 12 patients observed at the Harriet Lane Home who were tuberculin tested, only 5 gave positive reactions. Three other cases were definitely associated with active rheumatic fever; in one instance a new valvular lesion followed the attack. Erythema nodosum has been regarded as an allergic reaction, but it seems most probable that it is a toxic response that can be produced by a variety of agents. Typical instances have been observed in bromide and iodide poisoning.

### HERPES

*Herpes simplex* has been described in connection with diseases of the mouth and lips, for it is here that it most commonly manifests itself.

*Herpes zoster* bears no relation to herpes simplex. It is a local manifestation of disease in the posterior root ganglia, as a result of which lesions appear in the corresponding cutaneous segment. Instances are on record in which typical zoster lesions have been associated with Pott's disease, with tumors of the spine and even with meningitis, indicating that the lesion is a nonspecific one. In the majority of cases, however, herpes appears to be the result of some benign process of unknown etiology. A lymphocytosis may occur in the spinal fluid.

The lesions may appear in any part of the body—they are much more common on the trunk or head than on the extremities. The process seldom affects more than one or two adjacent segments and is usually unilateral. The lesion appears suddenly as a group of papules, many of which soon become vesicular. They do not itch and rarely last more than a few days. There may be mild constitutional symptoms, but more often these are wanting.

The diagnosis is not difficult in view of the characteristic distribution of the lesions. The only treatment is to prevent secondary infection if the vesicles rupture.

The view that herpes zoster is a manifestation of varicella is discussed elsewhere. It is based chiefly on epidemiological evidence.

### KERATOSIS PILARIS

This condition is characterized by small firm papules, with central horny spines, which are discrete and noninflammatory. It occurs characteristically around the hair follicles on the extensor surfaces of the arms and legs, and occasionally elsewhere, giving the skin a harsh, sandy texture. Salicylic acid ointment is helpful.

### LICHEN PLANUS

This is a rare disease in children, of unknown etiology, characterized by the appearance of red or purplish, round or angular papules, from a pinhead to split-pea size. The papules may be umbilicated and often show some scale formation. There is considerable itching. The disease may come on acutely with constitutional symptoms and a generalized eruption, or it may develop insidiously, beginning in



one or more of the sites of predilection. Characteristically the face is spared, and the eruption is more prominent on the extremities than on the trunk, favorite sites being the flexor surfaces of the hands and forearms and the inner surfaces of the knees and thighs. It may involve the mucous membrane of the mouth. The lesions remain dry and are usually symmetrically distributed. The disease runs a chronic course, but is often improved by preparations of arsenic or mercury. Antipruritic lotions are indicated.

### PITYRIASIS ROSEA

This is an acute self-limited disease of unknown etiology, which apparently affects the skin alone; it is usually unaccompanied by constitutional symptoms. It is characterized by the appearance of irregular maculopapular lesions with a tendency to central clearing. They are usually more profuse on the trunk, involving to a lesser extent the arms and thighs. The lesions tend to be parallel to the ribs. There may be slight itching. A frequent feature is the onset with a single large lesion—the “herald patch.” This precedes the other lesions by several days. The disease lasts three to six weeks and then gradually disappears. Recurrences are unknown. No treatment is required.

### PSORIASIS

This is not a very rare condition in children over five years of age; the youngest case seen at the Harriet Lane Home was three years old. The disease tends to run in families. The eruption consists of circumscribed red patches of varying size, which may be found over any part of the body, but particularly on the trunk, the scalp and the regions about the knee and elbow. It is usually symmetrically distributed. The most characteristic feature is the extensive silvery scale which, when picked off, uncovers a few bleeding points. The lesions are always dry; they grow by direct extension rather than by the appearance of new lesions near the margin of the old. The disease is exceedingly chronic, and has a marked tendency to recur when apparently cured.

Chrysarobin ointment, from 1 to 5 per cent, is considered by some to be a specific for psoriasis in children. It stains the clothing, the normal skin and hair; it is irritating to some individuals and must therefore be used cautiously. Particular care should be taken to keep it away from the face and eyes. Bathing should not be permitted during the period of treatment. As a rule great improvement or even complete disappearance of the lesions occurs within a week. Actinic rays are helpful.

### SCLEREMA

Sclerema neonatorum is a condition characterized by solidification of the subcutaneous fat. It may occur in circumscribed areas or extend over nearly the entire body. It affects infants who are very feeble and usually terminates fatally. Although sclerema is chiefly seen in the first days of life it is not limited to the newly born, but may occur at any time during the first few months. It is not to be confounded with edema of the newly born, with which condition it is, however, sometimes associated. From published reports it appears to be of not very infrequent occurrence in Europe, chiefly in large foundling asylums. In America,



sclerema is a rather rare disease. In the newly born, sclerema affects those who are premature or very feeble, sometimes those who are syphilitic. Later it may follow any condition leading to extreme cachexia, especially the different forms of diarrheal disease when accompanied by marked dehydration.

The first thing to attract attention is usually the induration of the skin. It is often seen first in the calves or the thighs, sometimes first in the cheeks, but soon extends over the greater part of the body. It is especially marked in the cheeks, buttocks, and back, and regions where adipose tissue is abundant. It may affect the body uniformly or in circumscribed areas. The skin may be smooth or may appear somewhat lobulated. The color is normal or slightly bluish, often tinged with yellow. The lips are blue, and the capillary circulation so feeble that after pressure upon the nails the blood returns slowly or not at all. The limbs are stiff and board-like. The skin is cold to the touch, and often the thermometer in the axilla will not rise above 90° F. In one recorded case the axillary temperature was only 71° F. The general feeling of the body has been well likened to that of a half-frozen cadaver. The tongue and the mucous membrane of the mouth are cold; the radial pulse often cannot be felt; respiration is slow, irregular, embarrassed, and at times respiratory movements are scarcely perceptible. The cry is a feeble whine, scarcely audible. The duration of the disease is usually from three to four days. Death occurs slowly and quietly. If recovery takes place there is gradual improvement in the circulation and nutrition, and, later, a disappearance of the areas of induration.

Several factors are concerned in the production of sclerema. In the first place, the body fat of the newly born infant is peculiar; it contains less olein and hence has a higher melting point than adult body fat. During the first year this gradually becomes altered, and at the end of the first year the infant's body fat resembles closely that of the adult. It is apparent that during the early months the infant's body fat is especially vulnerable in that a fall in skin temperature may cause it to solidify. Any condition which impairs the circulation is likely to cause a marked drop in skin temperature. This may occur in the newly born, or subsequently. In later infancy diarrhea with dehydration is the commonest cause of circulatory stasis, and it is in such dehydrated infants that late sclerema is seen. Whether some other factor in addition to the peculiarity of the fat and the low skin temperature is required to initiate the solidification of the fat is not known. In the newly born atelectasis is often found at autopsy and it is possible that incomplete aeration of the blood may play a part. Microscopic and chemical examinations of the fat of normal and sclerematous infants of the same age have not revealed any striking differences.

The prognosis is very bad, because of the grave conditions of which it is the expression, but it is not invariably fatal. In its milder forms, where treatment is begun early, recovery may take place. The diagnosis is to be made from edema by the fact that there is no pitting upon pressure, by the rigidity of the body, and by the great reduction in the skin temperature. The most important thing in treatment is artificial heat; the infant should be placed in a very warm room. The general nutrition should be promoted by careful feeding and all other means possible.



In infants who recover from sclerema—usually mild cases, to which the name *pseudo-sclerema* has been applied—the x-ray often reveals minute calcified areas scattered through the subcutaneous fat. Some observers regard this condition as different from true sclerema and many such cases are reported in the literature as “fat-necrosis of the newly born.” It seems likely, however, that there is no essential difference between these cases and the rapidly fatal scleremas of the newly born. When solidification of the fat occurs, crystals of neutral fat are deposited and a typical foreign body reaction develops about these after a time. Harrison has shown in such instances that these areas are rich in calcium and phosphorus even though no calcification has yet appeared and it therefore seems probable that calcification is only a final stage in the process.

### SCLEREDEMA

As described, this is a hard, brawny, pitting edema which makes its appearance during the first week or ten days of life in weakly infants. It is often associated with sclerema, and it seems probable that it is not in itself a disease entity, but very likely only the combination of sclerema with the idiopathic edema sometimes seen in the newly born. The condition begins on the dorsum of the feet and may spread to involve the entire body except the front of the chest. The genitalia are particularly likely to be involved; sometimes the edema is confined to them.

Except in those cases complicated by sclerema this edema need occasion no concern, for it tends to clear up spontaneously.

### SCLERODERMA

This is an uncommon disease seen in late childhood in which the skin becomes hardened and leathery. It may be confined to a single small area (morphea) or it may be diffuse, involving large areas of the body. The condition appears to be a trophoneurosis; the localized cases are often confined to the distribution of a peripheral nerve (linear scleroderma). The face and the extremities are most frequently attacked. In the early stages there may be edema of the affected region; subsequently this disappears and there remains an ivory white patch with a surrounding red border. Extensive fibrosis is found in old lesions. Contractures are likely to occur and interfere with muscular movement. The patient may be “hide-bound”; his facial expression is often mask-like. The disease is spoken of as sclerodactylia when it involves the fingers and toes. There may be marked impairment in the growth of affected extremities. When the condition is unilateral the good extremity may outgrow its fellow.

General hygienic measures, with massage and exercises to prevent contractures, are indicated. Thyroid should be given in large doses. Favorable results have been reported following deep x-ray treatment of the spinal nerve roots.

### SEBORRHEA

Seborrhea is generally considered a functional disease of the sebaceous glands, although Unna regards all such cases as inflammatory and classes them as seborrheic eczema. The disease may affect almost any part of the body, and children



of any age, but the most frequent form is that which is seen upon the scalp in young infants.

Seborrhea of the scalp is characterized by the formation of dirty-yellow crusts, which are soft, greasy, and friable. They are composed of epithelial cells, fat-globules, and granular masses, to which is always added dirt. In neglected cases the hairy scalp is nearly covered by a dense crust, which may be as thick as heavy pasteboard. If the crusts are removed the underlying scalp may be found perfectly healthy, but more frequently, in cases of long standing, it is eczematous. The eczema is set up by the decomposition of the exudation, or by the efforts to remove the crusts. There is little tendency to spontaneous improvement or recovery, and the condition often lasts for months.

Only local treatment is required. The crusts are first to be softened with oil, and then removed by washing thoroughly with warm water and soap, after which an ointment of resorcin, 2 per cent strength, or of sulphur, 10 per cent strength, should be applied. The oil and soap and water are repeated every few days, or as often as the crusts form. In the meantime the scalp is kept covered with the ointment.

**Seborrheic Dermatitis.**—In patients with the seborrheic habitus, eruptions appearing in response to inflammation in any part of the body tend to show certain common characteristics: there is an excessively active inflammatory response, with redness and often elevation of the lesions, and with induration and infiltration of the underlying skin; desquamation is increased, and the flakes of cornified epithelium have a greasy consistency and at times a yellowish color from their high fat content. Individual patches may resemble the lesions of psoriasis. The distribution and form of these lesions depend primarily on the underlying source of irritation; they may arise from mechanical causes, as in intertrigo, from chemical irritation, as in the “diaper rash,” or may even follow burns. The most common source, however, is bacterial infection. The dermatitis in these cases is not sharply localized and is quite superficial, the organisms being generally confined to the horny layer of the skin. In cases of long standing the lesions strongly resemble those of allergic eczema; they may be differentiated by their distribution, by the fact that seborrheic dermatitis shows somewhat less weeping, and by the absence of the specific manifestations of protein hypersensitiveness.

A special form of seborrheic dermatitis found principally in infants in the first three months of life is the *erythrodermia desquamativa* of Leiner. Early in the disease there is a macular erythema, appearing usually first on the trunk; the individual lesions are more or less circular in shape, from 2 to 20 millimeters in diameter, and are partly covered or rimmed by a branny desquamation. Later these areas coalesce, and in time the entire body is involved, the skin being everywhere red and beefy, thickened and indurated. In the most severe cases the desquamation occurs in large flakes, a form of dermatitis exfoliativa. The nutrition may suffer, and in about a quarter of the cases the condition is fatal.

Treatment should at first be directed toward removal of the irritating factor, which, except in the cases of intertrigo and diaper rash, may be regarded as an infection. The skin should be thoroughly cleaned with soap and water and a mild bactericidal ointment applied, such as 5 per cent sulphur or one-third strength



ammoniated mercury ointment, and this may be repeated once or twice a day. In small infants with severe infiltration of the skin it is wise to begin with applications of bland oil for a few days before going on to more vigorous measures; and even in the mild cases one must avoid aggravating the lesions by the use of too strong and irritating preparations. Later, when improvement has set in, the irritability of the skin may be diminished by graduated sun baths or the use of ultra-violet light from an artificial source. Seborrheic dermatitis is not conspicuously influenced by dietetic measures.

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## SECTION XV

### DISEASES OF ALLERGY

Allergy, strictly speaking, means abnormal reactivity. Pirquet, the inventor of the term, used it in an extremely broad sense to include even such phenomena as the increased susceptibility to cancer in later life, but in common usage—to which we shall adhere—the term allergy is applied only to the phenomena of hypersensitiveness to specific substances, mediated by *antigen-antibody reactions*. So far as is known, only proteins can act as antigens (give rise to antibodies). The various instances of hypersensitiveness to simpler substances are attributed to the fact that these latter are capable of uniting with proteins to form antigens.

**Classification of Allergic Phenomena.**—Four main types of allergic phenomena are met with: (1) hypersensitiveness of infection; (2) anaphylaxis; (3) serum disease, and (4) various forms of hypersensitiveness such as eczema, urticaria, angioneurotic edema, hay fever, asthma, and certain digestive and nervous manifestations, which have in common a strong hereditary basis. The term “atopy” is often applied to this last group of conditions—the specific excitants being known as *atopens* and the specific antibodies as *reagins*. With hypersensitiveness of infection and anaphylaxis constitutional factors play little or no part, the condition being brought about by the infection or (in the case of anaphylaxis) by previous treatment with an offending antigen. In serum disease and atopy, however, constitutional factors are of importance; serum disease shows a definite racial incidence and atopy a striking hereditary and familial influence.

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## CHAPTER XCVI

## HYPERSENSITIVENESS OF INFECTION; ANAPHYLAXIS

**Hypersensitiveness of Infection.**—Accompanying certain bacterial infections there develops a characteristic state of hypersensitiveness to the infecting organisms or their products. The most extensively studied example of this group is hypersensitiveness to tuberculin, but reactions of this type have also been demonstrated in typhoid fever, glanders, undulant fever and in ringworm infections; the luetin reaction belongs in this category. Similar allergic reactions have been demonstrated during and following some of the virus diseases with living or heat-killed virus.

The characteristics of this form of hypersensitiveness are: (1) it follows infection regularly regardless of constitutional predisposing factors; (2) administration of the antigen calls forth a *delayed* local reaction (usually requiring from six hours to three days to develop) which is inflammatory but does not exhibit pruritus or whealing; (3) larger doses call forth a focal and constitutional reaction as well; the latter, however, does not resemble anaphylactic shock; (4) eosinophilia is absent; (5) specific precipitins cannot as a rule be demonstrated in the serum, nor can this type of sensitiveness be transferred passively to human skin; (6) complete desensitization is possible, in contrast to other forms of allergy.

This type of hypersensitiveness is thought by some to be a more primitive response. Thus Dienes, who sensitized tuberculous guinea pigs by injecting egg white into their tuberculous lesions, observed that hypersensitiveness to egg white of the tuberculin type developed first; later this passed over into the usual type of hypersensitiveness. Hypersensitiveness of the tuberculin type has been observed with some of the common pyogenic organisms. In other instances these may give rise to the more usual type of allergy characterized by an immediate skin reaction with wheal formation and eosinophilia. The distinction between the two types is not an absolutely sharp one. *Streptococcus scarlatinae* toxin gives a delayed skin reaction without wheal formation, but there is frequently eosinophilia.

**Anaphylaxis.**—This term indicates a state of increased susceptibility brought about by a previous sensitizing injection. The hypersensitiveness may be local or general. *Generalized anaphylaxis* is a phenomenon largely confined to the lower animals. The sensitizing injection may be the allergen itself (active sensitization) or it may be antibody derived from another animal (passive sensitization). If, after a suitable interval, a second injection of allergen is made symptoms of acute anaphylactic shock ensue. These vary in different animal species, but have in common a spasm of smooth muscle which may be more marked in some parts of the body than in others. A fatal result often follows and may be caused by bronchial spasm (as in the guinea pig) or pulmonary artery spasm (as in the rabbit). Generalized anaphylaxis can be produced regularly in many of the lower animals, but its experimental production in monkeys and higher apes has met with little success. It is questionable if it occurs in man, although the accelerated form of



serum disease after reinjection of a foreign serum has been regarded as an anaphylactic manifestation. Severe constitutional reactions with smooth muscle spasm which may terminate fatally are occasionally seen in man following diagnostic or therapeutic injections of foreign protein. The symptoms resemble closely those of anaphylactic shock in the guinea pig, and they are often spoken of as such. There is, however, the difference that probably in all of these human instances the hypersensitiveness is constitutional, rather than induced by previous injection. Whether or not the mechanism is identical with that of anaphylactic shock in the animal is an open question.

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## CHAPTER XCVII

### SERUM DISEASE

The usual form of the disease is characterized by an incubation period, fever, malaise, various skin eruptions, of which the commonest is urticaria; often there is transient enlargement of the lymph nodes and spleen; less frequently there may occur myalgia, arthralgia or nervous manifestations. Symptoms last from a few hours to more than a week, but eventually subside completely.

This type of allergic response occurs in individuals who have had no previous contact with the excitant. It seems to depend upon a constitutional susceptibility, but one which is unrelated to the various atopic forms of hypersensitiveness; it occurs quite as frequently in nonatopic individuals. Serum disease is by no means the only representative of this group of phenomena. A similar response may follow the injection of any foreign protein in sufficiently large quantity. Certain forms of hypersensitiveness to drugs and parasites present close similarities. Serum disease is, however, the most important member of the group—the only one which will be discussed here.

**Incidence.**—More than 90 per cent of the white race is susceptible to serum disease and will develop symptoms if a sufficient quantity is given intravenously. If less than 10 c.c. is given (Mackenzie) symptoms appear in only 10 per cent, whereas if more than 100 c.c. is given, fully 90 per cent exhibit symptoms. These figures were obtained on adults, but the studies of Coca indicate that susceptibility is uninfluenced by age; it is present at birth and remains constant throughout life. Serum disease is less likely to develop after subcutaneous than after intravenous injections. The serum of certain horses is more likely to cause it. It is more likely to develop following the injection of immune serum than of normal horse serum, and among the various immune sera antiscarlatinal serum seems to be a particular offender (W. H. Park). Reactions are more frequent with fresh serum than with old serum; they are more frequent with whole serum than with refined products where only the pseudoglobulin fraction is employed.

Among the animal sera, beef serum gives fewer reactions than horse. Serum disease has in rare instances followed the injection of human serum, a phenomenon the interpretation of which is doubtful.

Complete immunity to serum disease is rare in the white race. In full-blooded Indians and full-blooded Negroes this is not uncommon.

**Immune Reactions.**—If a nonsusceptible individual receives an injection of foreign serum, the foreign protein remains in the circulation for many months, and no antibodies are demonstrable. In susceptible persons, however, although the foreign protein appears in the blood promptly, within a few days specific precipitins are found and, as their titer mounts, the foreign protein disappears. The time of removal of foreign protein coincides with the symptoms of serum disease. Anti-



bodies capable of passively sensitizing human skin appear at about the same time as the specific precipitins. Heterophile antibodies also develop with great frequency in serum disease; after the injection of horse serum one may find specific antishoop agglutinins and hemolysins. These various antibodies may persist for months or years.

**Symptoms.**—The incubation period varies from a few hours to twenty-one days, but in the majority of instances it is not far from seven days. Fever is often the first manifestation; however, it may coincide with the eruption and may even be postponed until the latter is subsiding. The fever may be of any degree; it is usually remittent in character. There may be mild headache or malaise.

The most constant feature of serum disease is the eruption. This often appears at the site of injection some hours before it becomes generalized; it is always prominent at the local site. The onset of the eruption may be heralded by dermatographia and itching, which is soon followed by redness and urticaria. Wheals appear first at the local site, then over points of pressure and finally on any part of the body. Angioneurotic edema is not infrequent and may involve the eyelids, lips, tongue or large areas on the face and extremities. The edema often causes a spurious gain in weight. Rarely other forms of eruption occur; scarlatiniform rashes are next in frequency; morbilliform eruptions, various types of exudative erythema or purpura may occur; combinations of these may be met with. An enanthem is rare in serum disease.

Other general symptoms that may be seen are enlargement of the lymph nodes and spleen, myalgia—particularly of the trapezius muscle—and arthralgia; joint swelling is rare. Enlargement of the lymph nodes and arthralgia are usually more marked near the site of injection. Nervous symptoms are seen in the severest cases: vomiting, delirium and convulsions have been reported. A transient albuminuria is not uncommon. The blood often shows a mild leukocytosis at the onset which may be followed by leukopenia. Eosinophilia is quite characteristic. The platelets may be increased.

The ordinary form of serum disease rarely lasts more than three or four days, and although the symptoms may cause a great deal of discomfort, they are not alarming and the prognosis is invariably good.

The diagnosis rarely offers difficulties if it is known that serum has been given. When constitutional symptoms precede the eruption one may fear some septic complication until doubt is dispelled by the appearance of urticaria. The eruption itself—even when morbilliform or scarlatiniform—rarely causes confusion with these diseases; the absence of an enanthem in serum disease is a helpful point. We have seen a case in the preëruptive stage in which myalgia and consequent generalized rigidity were so marked as to be mistaken for tetanus.

**Treatment.**—There is evidence that the symptoms can be ameliorated, possibly at times aborted, by salicylates in large doses given in the incubation period. Epinephrine is of undoubted value in controlling the urticaria. Other treatment is purely symptomatic—sedatives and antipruritic skin lotions, such as calamine lotion or 5 per cent bicarbonate of soda. Cold compresses may give marked relief.

**Acute Serum Reactions (Accelerated Form of Serum Disease).**—In two groups of individuals the reaction to serum shows distinct alterations from that



described—those who have been sensitized by a previous injection of serum and those who exhibit atopic hypersensitiveness to horse serum.

A subject who has received serum usually develops after two to three weeks a state of hypersensitiveness which lasts for months or years. This may be the case even when the first contact was not followed by recognizable serum disease. It has been known to be induced by the small quantity of horse serum (0.0001 c.c. per dose) used in the toxin-antitoxin prophylaxis of diphtheria.<sup>1</sup> The sensitized patient usually exhibits a positive cutaneous reaction to horse serum, and specific antibodies can be demonstrated by the precipitin method and by passive transfer. In such patients a reinjection of small amounts of serum (5 to 10 c.c.) produces the symptoms characteristic of serum disease, but with a relatively short incubation period. The manifestations may come on within a few hours or even immediately following the injection. As a rule they are not more severe than in the usual type of serum disease. A few instances have been reported in which acute symptoms resembling anaphylactic shock have followed such reinjections—the reaction being characterized by asthma and circulatory collapse in addition to extreme urticaria and edema. However, this danger has without a doubt been greatly exaggerated. The acute fatalities following serum injection have occurred almost exclusively in subjects of atopic hypersensitiveness to horse.

The individual who is atopically hypersensitive to horse serum usually develops an immediate reaction on its first administration, the severity of which depends on the degree of hypersensitiveness and the quantity of serum given. There are records of fatalities following the injection of 1/20 c.c., and of severe constitutional reactions following smaller amounts. The detection of such individuals is of the greatest practical importance if therapeutic serum is to be given, and by means of a careful history and specific tests it is usually possible to do this. A history of any form of atopic hypersensitiveness—asthma, hay fever, urticaria or eczema—either in the patient or in the immediate family is an absolute indication for a skin or a conjunctival test. Even for the patient who does not give an allergic history it is a wise precaution to inject 0.1 c.c. of undiluted serum intracutaneously; if a wheal 2 centimeters or more in diameter does not appear within twenty minutes one may proceed without hesitation. With an allergic history diluted serum should be used for testing. An intradermal test should be made with 0.05 c.c. of a 1:100 dilution, or, better still, an ophthalmic test with 1 drop of a 1:100 dilution. The ophthalmic test is of distinctly greater value; a number of instances are now on record in which a high degree of sensitiveness was revealed by the ophthalmic but not by the skin test. The converse is not true; if the eye has been tested nothing is to be gained by a skin test.

**Administration of Serum to Hypersensitive Individuals.**—In the non-atopic individual with a positive skin reaction which can be attributed to a previous injection of appreciable amounts<sup>2</sup> of serum, it is probably safe to give small amounts of serum (5 to 10 c.c.) cautiously. A syringe of epinephrine should always

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<sup>1</sup> In recent years (especially since 1929) sheep or goat serum has usually been employed in toxin-antitoxin mixtures.

<sup>2</sup> This does not apply to those who have received only the minute amounts of serum used in toxin-antitoxin diphtheria prophylaxis, for these rarely leave appreciable hypersensitiveness.



be available in case respiratory symptoms develop; immediate cutaneous reactions or even a chill may occur, but need not occasion concern. Whether larger amounts of serum can be given to such persons with safety is not known. Should the hypersensitiveness be extreme (skin or ophthalmic reaction to 1:100 dilution) it is a wise precaution to inject the serum in small amounts, starting with  $\frac{1}{2}$  to 1 c.c. at a dose, and waiting twenty minutes between each of the first few injections to see if alarming symptoms develop.

In the individual atopically sensitive to horse serum (i.e., one whose sensitiveness cannot be attributed to a previous injection) the following rules apply:

1. With a positive skin or conjunctival reaction to a 1:100 dilution of horse serum, the injection is contraindicated.

2. If a reaction is obtained only with undiluted or 1:10 serum, it is justifiable to proceed very cautiously; the first injection should not exceed  $\frac{1}{20}$  c.c. and the amounts should be slowly increased, waiting twenty minutes between injections.

3. Injections should be made into an extremity, not into the buttock, so that a tourniquet may be applied if alarming symptoms develop. At the first evidence of respiratory symptoms, itching, or any peculiar subjective sensation, epinephrine should be given and no further serum administered.

If these precautions are followed, one may reasonably expect to avoid the rare fatalities resulting from serum injections. One or two deaths have, however, been recorded in patients with negative cutaneous and ophthalmic tests.

Horse dander should not be substituted for horse serum in testing for serum sensitiveness. Although most patients sensitive to dander are also serum-sensitive, this is not invariably the case. A few patients are dander-sensitive, but can take serum with impunity; it should, however, be given cautiously if there is a history of horse asthma or the patient is known to be dander-sensitive, even if serum itself gives negative tests.

**Desensitization.**—It was formerly believed that patients hypersensitive to horse serum could be desensitized by the administration of serum in quantities below the level of symptoms, these being gradually increased at half-hour intervals. Although rapid desensitization (within twenty-four or thirty-six hours) can be accomplished by this means in anaphylactic animals, it is now the general opinion that this does not occur in man. Instances in which skin reactors have been “desensitized” and given appropriate quantities of serum successfully have been either patients rendered allergic by a previous injection, in whom pulmonary symptoms and fatal shock are practically unknown, or atopic subjects whose hypersensitiveness was not extreme. The difficulty of desensitization in the extremely sensitive patient is well illustrated by the experiences of Kerley, Tuft and others.

There have been several instances in which sensitive individuals have received an overdose of protein causing the most alarming symptoms of shock with asthmatic manifestations but without a fatal outcome. Upon recovery they were found completely refractory not only to the specific protein which had produced the shock but to other proteins as well. Such a refractory state has lasted for months, sometimes for years. It seems probable that rapid general desensitization can be accomplished only by a procedure causing severe shock, and the dangers inherent in the method make it unjustifiable.



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## CHAPTER XCVIII

### DISEASES OF HYPERSENSITIVENESS (ATOPY)

**General Considerations.**—The diseases which can with certainty be attributed to hypersensitiveness to specific agents are eczema, urticaria, angioneurotic edema, hay fever and asthma. To these must be added the condition of general protein shock, occurring when an offending antigen is taken in doses well above the tolerance. Protein shock is not confined to therapeutic or diagnostic parenteral injections; it may occur after the ingestion of the offending substance in highly susceptible individuals, giving rise to digestive symptoms (vomiting, diarrhea, abdominal pain) or to neurocirculatory symptoms (sudden pallor, collapse). Certain other diseases have been attributed to hypersensitiveness, although the relation is not definitely established; among these may be mentioned purpura of the Henoch-Schönlein type, migraine, certain cases of epilepsy, celiac disease, and certain bladder disorders.

**Incidence.**—The importance of the atopic diseases in childhood is seen from the following statistics showing the incidence of the chief manifestations in 74,000 admissions to the Harriet Lane Home in Baltimore:

	<i>Cases</i>
Eczema .....	2960
Urticaria .....	517
Angioneurotic edema .....	55
Hay fever .....	22
Asthma .....	487

The data were compiled before a special clinic for these conditions was established, and therefore represent average pediatric experience.

The age incidence of these conditions varies considerably. Eczema generally appears within the first six months of life, and is usually confined to the first two or three years. Typical urticaria and angioneurotic edema are uncommon before the latter part of the first year but may be seen at any time. Hay fever is uncommon before puberty, but may occur in young children. The youngest case at the Harriet Lane Home was in a child three years old. Asthma may begin in infancy, but in most instances the onset is after the third or fourth year. It is not uncommon for a patient to recover from eczema at the end of the second year only to fall a victim to asthma, which may last throughout childhood and then be superseded by hay fever.

Allergy to particular groups of offending substances likewise shows a definite age incidence. In infants the ingestants (food hypersensitiveness) comprise almost all of the cases, while inhalants (mostly the pollen and epidermal group) come into play about the beginning of the school age. Stuart and Farnham found that 85 per cent of their allergic patients under two years of age were sensitive to



foods; at four years ingestants and inhalants were of equal importance, and after the eighth year there was a marked increase in the importance of the inhalants, while only 15 per cent were food-sensitive. Foods continue to be responsible for a few cases of eczema, urticaria, angioneurotic edema, migraine and anaphylactoid purpura in older patients.

The influence of heredity in the diseases of hypersensitiveness is well known. In approximately 70 per cent of the cases a positive family history can be obtained, whereas the incidence of an allergic family history in the juvenile population at large is less than 10 per cent. The observations of Cooke indicate that when the hereditary factor is marked, particularly when there is a bilateral family history, allergic manifestations appear earlier. Balyeat has made similar observations in regard to infantile eczema. Sometimes a hereditary susceptibility to particular excitants or groups of excitants is seen, but frequently this is not the case. Hereditary atopic hypersensitiveness does not appear to follow mendelian laws; according to Bray asthma is transmitted twice as frequently by the female. Many observers have noted that where there is multiple sensitiveness, a family history is nearly always obtainable, whereas this is less frequently true when the sensitiveness is confined to a single excitant.

**Immune Reactions.**—The state of atopic hypersensitiveness in man, when fully developed, presents much in common with anaphylaxis as it occurs in the lower animals. Eosinophilia is common to both; in both conditions there is sensitiveness of the skin and mucous membranes with an immediate response (within twenty minutes) which in the skin is characterized by pruritus and wheal formation. With overdosage of the antigen a similar type of shock reaction with smooth muscle spasm is obtained. The serum in both conditions will passively sensitize human skin. Coca, who believes that the two states are essentially different, lists the following points of difference:

<i>Anaphylaxis (Animals)</i>	<i>Atopy (Man)</i>
1. Generalized shock occurs only after intravenous injections	1. It may follow subcutaneous injection
2. Complement fixation positive with serum	2. Complement fixation fails or is atypical
3. Precipitins present in serum	3. Precipitins usually absent
4. Serum neutralizes antigen <i>in vitro</i> rapidly and regularly	4. Serum usually fails to neutralize antigen <i>in vitro</i> (may do so very slowly)
5. Passive sensitization of guinea-pig uterus regularly possible	5. Rarely successful
6. The antibody capable of passive transfer to human skin is more thermostable	6. The antibody transferable to human skin (the "reagin") is more thermostable
7. The antibody transferable to human skin has less tissue affinity:	7. (a) Passive sensitization lasts four to five weeks
(a) the duration of such sensitization is transient	(b) The site is less readily exhausted by reinjection of antigen
(b) the site is more readily exhausted by reinjection of antigen	
8. Complete desensitization is possible at will	8. Desensitization is only partial and irregularly obtainable

The significance of these differences is questioned by other immunologists.



**Pathogenesis of Atopic Hypersensitiveness.**—This subject is still obscure. Parenteral contact or absorption of foreign protein is apparently necessary for the development of specific antibodies, and without these symptoms do not occur. Instances in which infants react to the first administration of a food may be due to intra-uterine contact with the antigen. Although parenteral contact is a requisite for the development of sensitiveness, this alone is not sufficient. It is now known that parenteral absorption of unaltered protein is a common occurrence in normal individuals. Schloss and his coworkers have shown that following the first administration of a protein a normal infant will usually develop skin sensitiveness, precipitins and antibodies capable of passive transfer. Symptoms, however, do not appear, and in the course of a few weeks the skin reaction and the antibodies disappear. Subsequent administration of the same protein fails to reproduce the phenomenon, though it usually reappears with each new protein added to the diet. Walzer has demonstrated that parenteral absorption of foreign protein is continually occurring in normal adults. He sensitized skin sites with serum from allergic individuals, and was able to produce a local reaction when the normal passively sensitized individual ingested the particular food in question.

Just how the individual who exhibits clinical hypersensitiveness differs from the normal is not known. After his preliminary contact with the offending substance he usually remains skin sensitive and his serum retains the power of passively sensitizing human skin, though not of precipitating the antigen. There is, however, no parallelism between the skin sensitiveness, the sensitizing power of the serum and the development of symptoms. A young child may be skin sensitive to a pollen and his serum may be capable of passive sensitization, yet he exhibits no symptoms when brought in contact with this substance, although years later its presence may bring on asthma or hay fever. It is also possible for clinical symptoms to abate or disappear entirely—either spontaneously or as a result of treatment—and yet skin sensitiveness and the passive transfer reaction persist. The specific immune reactions in the atopic individual are of great importance; they are an indication of hypersensitiveness—past, present or future—but they do not explain the occurrence of the symptoms.

**Methods of Testing for Hypersensitiveness.**—There are four general methods available: (1) skin tests with the scratch or the intradermal technic; (2) tests for antibodies in the serum by the passive transfer method; (3) mucous membrane tests, and (4) environmental tests in which specific substances are either removed or introduced into the diet or environment.

**Skin Tests.**—Either the scratch or the intradermal technic may be used. The scratch method is more convenient for occasional use; it requires less paraphernalia in the form of sterile liquid extracts and the chance of constitutional reactions is reduced to a minimum. The intradermal method is more convenient for use in a clinic, or where tests are frequently made. Its advantages are that it does not require a fixed position of the arm; the reaction is more delicate and more accurate, since it can be titrated with known dilutions. However, it requires some familiarity with the dilutions of particular extracts which should be used for testing; otherwise constitutional reactions are likely to be frequent.

The scratch test is carried out by making a small aseptic scratch in the skin (it



is not necessary to draw blood) about 5 millimeters in length. If the substance to be tested is a liquid (horse serum, egg albumin) a drop of this is placed over the scratch and is allowed to remain there for twenty minutes, when the final reading is made. If the antigen is a solid, one may perform the test by covering the scratch with a drop of 0.1 normal NaOH and stirring into this a small amount of the powdered allergen with an individual applicator, or a liquid glycerin extract may be applied directly. A scratch with sodium hydroxide alone may serve as control. The test material should also be tried on normal skins.

With intradermal testing, glycerin extracts<sup>1</sup> of the material are used in appropriate dilution. Fewer false reactions are obtained when the quantity injected does not exceed 0.02 c.c. Cooke recommends the injection of only 0.01 c.c. Extracts of pollens, horse dander, rabbit hair, egg, castor bean, orris, and fish glue are among those that should be used in high dilution for testing if constitutional shocks are to be avoided. The typical skin reaction develops with somewhat greater rapidity than with the scratch technic; it is usually complete in fifteen minutes.

*Passive Transfer.*—This method of testing is often spoken of as the Prausnitz-Küstner reaction. Serum from the patient to be tested is injected intradermally into a normal recipient in different areas of the forearm, 1/20 c.c. being introduced in each area; the site is marked with ink. Although the area so sensitized will exhibit a skin reaction to the antigen within a few hours, it is desirable to wait a day or two before testing the recipient; this eliminates a certain number of false reactions. Passive sensitization so conveyed remains for four to five weeks. The same site can be tested over and over again if *negative* reactions are obtained. If a *positive* reaction is obtained that site should not be used again; it is likely to be refractory for several days, after which its reactivity may return. The reactivity of such a site may be exhausted completely by repeated testing with a reacting antigen. The intradermal technic is preferable for testing the passively sensitized individual. A control is performed for each test by making an identical injection into an unsensitized area.

Passive transfer tests are time-consuming and should not be used to replace direct tests as a routine. There are, however, certain definite indications for using them. They are of great value in abnormal skin conditions, among which may be mentioned diffuse eruptions of all kinds, ichthyosis and scarred or edematous skins which as a rule are hypo-active, also hypersensitive skins which exhibit dermatographia upon the slightest provocation, a common condition in young infants. Other indications are when there is objection to or lack of time for repeated testing of the patient, and in severe asthma demanding the constant use of epinephrine. Beyond a doubt the greatest value of the test is in ruling out false positive or doubtful reactions obtained in direct testing. With a direct skin test only reactions with a typical wheal can be accepted as positive, although erythema accompanied by pruritus is highly suggestive; erythema alone may or may not be of significance. With the indirect method any difference between the reaction in the sensitized and unsensitized site is significant, even if erythema alone is obtained in the former. Walzer gives the following precautions to be employed in performing passive transfer tests:

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<sup>1</sup> Such extracts, made according to the method of Coca, are now commercially available.



1. One should make sure that the recipient is suitable. In a certain proportion of persons (10 per cent of adults according to Coca) the passive transfer phenomenon fails.

2. The recipient should not be hypersensitive; otherwise, a reaction will be obtained in the control test.

3. The recipient should not eat foods for which tests are being made, for at least twenty-four hours previous to the test:

4. If any marked local reaction is obtained, further testing that day should be abandoned, for wheals may develop at untested sensitized sites as well.

5. The area of skin used for passive sensitization must be normal. Sunburned areas are to be avoided.

The donor should have a negative Wassermann reaction.

*Mucous Membrane Tests.*—The ophthalmic test has been mentioned in connection with serum disease; it is a valuable accessory procedure and sometimes reveals a condition of sensitiveness when the skin test is negative. A drop or two of the test solution or a small amount of dry antigen is placed in the conjunctival sac. The reaction appears as promptly as the cutaneous one: there is lacrimation, itching and congestion which is more pronounced in the lower half of the eye. Unpleasantly severe reactions can be controlled by the introduction of epinephrine in the conjunctival sac.

Direct testing of the nasal mucosa with sprays of various dilutions of excitants has been used in hay fever. By this means one can sometimes incriminate some one particular excitant in cases of multiple skin sensitiveness. Quantitative determinations of hypersensitiveness by this method must be interpreted with caution during the hay fever season; hay fever attacks tend to be paroxysmal, and following a paroxysm the mucous membrane may for a time be relatively refractory.

Direct testing of the bronchial mucosa by inhalation tests has a limited field of usefulness.

*Diet and Environmental Tests.*—In cases of multiple sensitiveness and those in which the skin tests have failed to reveal hypersensitiveness, a specific diagnosis can often be established by the introduction or removal of a particular substance from the diet or environment. Test diets are particularly useful in infants and young children, whose sensitiveness is nearly always to foods. They are also useful in unexplained cases of urticaria and angioneurotic edema at any age, since foods are usually responsible for these conditions, and for some reason the specific skin tests often fail. In early life the elimination method is more valuable. The most common offenders are milk, egg, wheat, oats, orange; diets adequate in all respects may be made up, omitting one of these at a time. In older subjects sensitiveness is more often to some unusual article of diet, and the introduction procedure is more convenient. After obtaining a complete list of the articles eaten during the twenty-four hours preceding the attack, one may put the patient on a very simple diet of a few familiar foods; as soon as the urticaria or angioneurotic edema has disappeared the suspected articles may be introduced one at a time.

Environmental tests to inhalants and contactants are likewise valuable. When inhalants are suspected, removal of the patient to a hospital room will often eliminate the offending substance; tolerance tests toward particular excitants can then



be carried out. Sometimes the history will point directly to a particular offender which can be eliminated. In tolerance tests it is important that the excitant be applied by the correct route. An individual may be sensitive to rabbit hair as an inhalant yet be able to eat rabbit meat with impunity.

**Practical Considerations in Use of Specific Diagnostic Tests.**—It is obviously impractical to carry out all possible specific tests in a patient suspected of hypersensitiveness. The number of excitants which have been at some time or other incriminated and are now available for testing are numbered by the hundred. Even if direct skin tests alone are employed, the task of covering the field is as stupendous as it is unnecessary.

Age is an important consideration. Under two years of age nearly all cases are due to food, and it is rarely necessary to go beyond the common foods in testing. Contactants are, however, not a very rare cause of infantile eczema; the most important members of this group are silk and wool; Balyeat found that approximately 10 per cent of his eczema patients reacted to silkworm extract. A small proportion of eczemas are due to inhalants.

A careful history will often give clues which will narrow down the possibilities and may indeed point to a single offender. One should inquire about the possible association of the symptoms with food, locality, season, clothing, animals, etc. The time of day or night at which symptoms of asthma appear may be important. Any leads so obtained should be followed up by skin tests.

In selecting the tests to be performed it is preferable to try not more than ten at a time; if at the end of half an hour no reactions are obtained, another ten may be tried, and so forth. Tests performed simultaneously should be in scattered groups—for example one or two pollens, danders, foods, and contactants may be tested simultaneously. By this means a lead is often obtained, for sensitiveness frequently exists toward several members of a group. A positive reaction in the group of pollens or danders, for instance, calls for a more complete investigation of that group. This method also decreases the chance of obtaining a constitutional reaction, which might result from the cumulative effect of a series of positive reactions in one group.

In interpreting skin reactions one must bear in mind the sources of error and the limitations of this method: the causes of false reactions, many of which can be eliminated by proper technic, and the possibility of true reactions which may be of no significance. *False positive reactions* may be due to an irritable skin (in which case one must resort to the passive transfer method); they may be due to errors in technic, such as placing the test sites too close to each other; or to the use of contaminated or irritating extracts. This last possibility can be discovered by a control test on a normal individual. *True positive reactions that may be of no significance* are: (1) the reaction described by Schloss in normal subjects following ingestion of a new food; (2) reactions in normal subjects that have received large doses of protein parenterally (horse serum); (3) reactions in atopic individuals that may indicate past or future clinical manifestations. Mucous membrane and environmental tests may eliminate some of these. *False negative reactions* may be due to a refractory skin (ichthyosis, scarring, edema); to technical errors (subcutaneous instead of intradermal injection), or to a deteriorated or otherwise



impotent extract. This last possibility can be checked by testing the extract on a known sensitive person. *True negative reactions in sensitive individuals* may occur temporarily under the influence of acute illness, shock, dehydration or after the administration of epinephrine. In other instances the nonreactivity of the skin may be permanent. A specific diagnosis can then be made only by mucous membrane or environmental tests; these, however, offer little prospect of success unless the history provides a definite lead; only a few such tests can be performed at the most. It is apparent that the ophthalmic test, the other local mucous membrane tests and the environmental tests are valuable as supplementary methods, but are of little use unless the skin tests or the history provide a definite clue.

The frequency with which specific hypersensitiveness can be demonstrated in the various allergic diseases varies considerably in different reports. With the more thorough study of these conditions, the improvement in antigens and in technic, the figures are steadily rising. The highest percentage of positive reactions is obtained in hay-fever cases, where specific hypersensitiveness can usually be demonstrated in more than 90 per cent of patients. In asthma and in eczema one can reasonably expect to demonstrate it in about 75 per cent. Lower figures have been obtained with urticaria and angioneurotic edema for reasons which are not altogether clear. Since these cases are likely to be less troublesome it may be that they have been less carefully studied, and it is also possible that the antigens have been at fault. Many of these patients are sensitive to unusual foods for which suitable antigens are not available. Another source of error is the testing of the patient with an extract made from raw antigen, whereas he may be sensitive to it only in the cooked state.

The task of diagnosis may be far from ended with the demonstration of some form of specific hypersensitiveness. Cooke has given the following two postulates necessary to establish the specific cause of the patient's allergic symptoms: (1) hypersensitiveness to a specific agent must be demonstrated by direct or indirect skin tests, mucous membrane or environmental tests; (2) the offending substance must be demonstrated in the patient's environment. This last may be a matter of great difficulty and is often essential to successful treatment. For example, an asthmatic may be shown to be hypersensitive to cat hair or rabbit hair, yet removal of the patient from the vicinity of these animals fails to relieve the symptoms. Eventually it may be discovered that a fur, a felt hat or a toy animal in the family contains the antigen in question. It is necessary to know the various industrial uses to which various offending substances can be put in order to detect their presence<sup>2</sup>—the components of various articles of clothing, of dress, cosmetics, foods, etc. Contact with individual foods may be occurring constantly when least suspected—for example, a vegetable to which a child is sensitive may have been excluded rigidly from the menu, but may be ingested in milk if the cow has been eating it.

The decision as to treatment—whether or not to attempt specific desensitization—will depend largely upon the ease with which the offending substance can be

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<sup>2</sup> An excellent summary of the occurrence and uses of various agents causing hypersensitiveness is given by Bowman and Walzer in *Asthma and Hay Fever in Theory and Practice* by Coca and others, Thomas, Springfield, Ill., 1932, pp. 368-462.



eliminated from the environment. With the exception of the pollens and house dust, which may be very difficult to avoid, desensitization is infrequently attempted in children. Sometimes with hypersensitiveness to common foods (milk, wheat, egg) and occasionally with other excitants it is more convenient to desensitize than to avoid.

**Specific Desensitization.**—This may be carried out by the oral route, by subcutaneous or by intradermal injections. Mackenzie has had some success with immunization by nasal sprays in hay fever, but the method has not come into general use.

The oral method is most frequently employed in cases of food allergy; it has been used successfully with pollens. Because of the variable factor of absorption it does not permit as accurate a control of dosage, but constitutional reactions are certainly no more frequent with this technic, probably less so. Its chief disadvantage, when used for other excitants than foods, is the added expense; only a small part of the oral dose is absorbed and at least ten times as much must be given. The annoyance of injections is, however, eliminated. Immunization by subcutaneous injections is still the standard procedure, although recent reports by Duke and others who have employed the intracutaneous route indicate that this is quite as satisfactory.

The principle is to start with a dose so small that no symptoms are produced and to increase this gradually by geometrical progression, each dose being a definite multiple of the one preceding (usually 1.5 to 1.8 times as large). If constitutional reactions are obtained the increase should be omitted and one should then proceed cautiously. It is often possible to build up such a tolerance that the quantity of the offending substance normally present in the environment can be borne without producing symptoms. With some proteins and in some subjects such complete desensitization is possible. With others, incomplete or no success is obtained; sooner or later, as the dose is increased, an *impasse* is encountered; beyond this limit constitutional reactions follow, no matter how cautiously the dosage is increased. This limit, in the case of pollens, is usually reached between 100 and 1000 times the original dose. It is not wise to go beyond the latter figure as a rule; in approaching it it is a good precaution to slow down the rate of increase with each injection to 1.2 times the preceding dose.

In choosing an initial dose one must be guided by the degree of sensitiveness as shown by the specific reactions on testing. It is not possible to prescribe absolute amounts. A safe initial dose is the smallest one that will give a positive intradermal test. The interval between injections depends on the route chosen. With subcutaneous immunization the safest procedure is to use an interval of three or four days, although the risk of reactions with a two-day interval is a small one. Rapid desensitization, in which injections are given at intervals of one-half hour in an attempt to desensitize completely within twenty-four hours, has been tried for pollens as well as for horse serum. As explained elsewhere this is an exceedingly dangerous procedure, not to be recommended. Constitutional reactions are certain to follow in highly sensitive patients. Such immunization as is obtained is probably nonspecific and results only from severe shocks. With oral administration or with intracutaneous immunization an interval of twenty-four hours can be used



routinely; the preceding injection is usually absorbed within this period and cumulative effects are not obtained.

The immunity obtained in hypersensitive subjects is very transitory; unless the specific substance is present in the environment or immunization is continued, it wanes rapidly. If a week or two has elapsed between injections an increase in dosage should not be made on the next treatment; if more than a month has elapsed the next dose should be decreased.

*Constitutional Reactions.*—These may occur as the result of a therapeutic or diagnostic injection, or from natural contact when the tolerance of the individual has been exceeded. The symptoms may be delayed for an hour or more, in which case they are rarely serious; or they may come on immediately. The onset may be with suffusion of the conjunctiva, rhinitis and sneezing or with cough or asthma. There is usually itching of the skin with urticaria and often angioneurotic edema. There may be sudden pallor, faintness and a feeling of shock or vertigo; sometimes there is headache, nausea, vomiting and abdominal pain or diarrhea. The pulse is weak, rapid, and may be irregular. In the attacks terminating fatally asthmatic symptoms have usually appeared to be the immediate cause of death. A fatal termination may occur within a few minutes, or the attack may clear up, usually within a few hours, sometimes only after a day or two. Albuminuria and general glandular enlargement are less frequent symptoms.

The prevention of such reactions is a matter of great importance; apart from the occasional fatalities these shocks are always distressing and often alarming. The great majority of reactions can be attributed to preventable errors in technic, such as an accidental injection into a venule, too many tests in a related group undertaken at one time, an improper interval between treatments, an excessive dose in commencing immunization or too rapid increase in dosage. In some instances reactions are unavoidable. A constitutional reaction calls for the prompt administration of epinephrine in doses up to 1 c.c. of 1:1000 dilution for a child of ten, and half this quantity for one of four. Walzer advises giving part of the injection locally and applying a tourniquet above the site of injection to limit further absorption. Sedatives may be indicated.

**Nonspecific Desensitization.**—A variable amount of desensitization can be brought about by nonspecific measures. Temporary anergic states may occur during infections or after the administration of epinephrine. The completely refractory state toward all offenders that may follow a very severe constitutional shock has already been referred to. It may last for months or even years. From reports in the literature it seems clear that desensitization toward one agent may result in some degree of decreased sensitiveness toward others. Desensitization with tuberculin in tuberculin-positive individuals, and with ascaris extract in those who react to this substance, has been followed by decrease in atopic hypersensitiveness. Favorable results have also been reported with a course of parenteral treatment with an allergen to which the patient is not sensitive; milk protein has been most frequently used. While the observations are of interest they offer nothing that is superior to specific therapy. Of greater practical importance are the more recent observations concerning the effect of diet and water balance on hypersensitiveness. The clinical observation has been frequently made that eczema and asthma were



made worse by high carbohydrate diets, and a number of instances are on record in which improvement followed the substitution of fat for carbohydrate. Rubin studied one patient in detail in whom eczema and asthma could be induced at will by replacing fat with carbohydrate; as is often the case this was accompanied by water retention. The same observer has demonstrated the anergic effect of dehydration in anaphylactic animals and has observed striking improvement in a number of cases of asthma following a dehydrating regimen. Similar observations have been made by others, and it would seem as if dehydrating diets were likely to prove a valuable adjunct in the treatment of eczema and asthma, though in hay fever they have met with little success.

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- See also references, page 725.



## CHAPTER XCIX

### ECZEMA

Eczema is the most frequent and altogether the most important disease of the skin in early life. By and large it is a disease of infancy. After the second year the predisposition ceases and throughout childhood it is relatively uncommon.

**Etiology.**—Two factors are of particular importance in causing eczema—a condition of hypersensitiveness, usually to foods, and the delicate character of the skin in infancy, as a result of which it is more susceptible to irritants. The attempt is sometimes made to separate allergic eczemas from those which are due to irritation. Although it is sometimes clear that irritation is almost solely responsible, as for instance in the familiar diaper rash and other forms of intertrigo (which are discussed elsewhere), a sharp distinction between irritative and allergic forms is not possible; in the majority of instances both factors are operative.

The allergic nature of eczema—now clearly established—explains many facts which were once obscure, such as the marked familial tendency, the association with asthma or other later allergic manifestations in the patient himself or in other members of the family, and the frequent occurrence of eosinophilia. Food allergy is confined chiefly to the time of life at which eczema is seen (six months to two years) a period during which many new articles of diet are introduced. Multiple sensitiveness is common, being found in 20 per cent of the cases studied by Balyeat. As the child grows older a tolerance to these foods usually develops spontaneously. At times this seems to result from immunization with small quantities taken in the food; in other instances the tendency is apparently outgrown; after a period of complete abstinence the offending food can be taken with impunity.

A number of accessory factors may play a part in the production of eczema. Eczema is rare in infants who are poorly nourished; it is especially common in those who are obese; it is certainly aggravated by overfeeding. The association with obesity is seen in the eczemas of later childhood as well. A diet with a high proportion of carbohydrate as compared with fat seems to predispose toward eczema; the observations of Rubin (referred to above) indicate that dehydration resulting from a higher fat intake may be responsible for the diminution of the tendency to eczema. An attack of diarrhea in an eczematous patient nearly always brings about marked improvement in the skin. During acute infectious diseases eczema may temporarily disappear. How much of this anergic state can be attributed to dehydration cannot be stated. Among the local irritants causing eczema may be mentioned atmospheric heat causing excessive perspiration, cold dry air and winds—as in the familiar chapping of the face and hands—the use of hard water or of strong soaps in bathing, the irritation of clothing, want of cleanliness or irritating discharges from the mucous surfaces as in eczema of the



upper lip, external ear, thighs or buttocks. Secondary infection is of frequent occurrence and is often responsible for keeping up the disease.

**Symptoms.**—In infants and young children, eczema is usually seen upon the face. It affects by preference the cheeks, forehead, and scalp, not infrequently the ears and neck, and may occur upon any part of the body. Upon the trunk and extremities the eruption is usually in patches, but in rarer cases may cover nearly



FIG. 116.—ECZEMA IN BOY SEVEN MONTHS OLD.

the entire body. The disease generally begins upon the cheeks with the formation of small red papules; later these coalesce, and there is a moist, red surface exuding serum. The secretion dries and forms thick, gummy crusts, which may be so hard as to form a mask for the face. From the scratching caused by the almost intolerable itching, the surface bleeds freely, and the dried blood gives to the crusts a dirty-brown color and adds to the distressing appearance. The skin is often swollen. After the removal of the crusts there is seen, in acute cases, a red, inflamed, granular surface, moist and bleeding readily. When the process is less active, there is redness, thickening, induration, and scaliness of the skin with marked itching. In the same case these stages may alternate, exacerbations occurring whenever the exciting cause is particularly active. From the cheeks the disease spreads to the



forehead, ears, and scalp, and here similar lesions are seen. Upon the trunk and extremities thick crusts rarely form, but the skin is red, thickened, and scaly. The parts most often affected are the forearms, legs, abdomen, and back; occasionally the eruption is general. Eczema limited to the occipital region of the scalp is usually due to pediculosis.

Swelling of the lymph nodes in the neighborhood of the eruption is a constant feature of eczema of the face and scalp; these may reach the size of a chestnut or walnut, and occasionally they may suppurate. With a generalized eruption all the superficial lymph nodes become enlarged, including the epitrochlears.

While most children with eczema are well nourished in the beginning, and some remain so during a prolonged attack, the general health of many is undermined. The itching and discomfort cause constant irritability, loss of sleep, and other nervous symptoms which sometimes seriously impair the nutrition of the child.

The effects of very extensive eczema resemble in some particulars those of burns of the second degree. There may be fever, delirium, other nervous symptoms and even a fatal termination. We have seen several cases with a generalized eczema in which there developed exceedingly high temperature, in two cases reaching 109° F., accompanied by symptoms of a most profound intoxication. Most of the infants with such symptoms die, but one child recovered in whom the temperature mentioned was reached. Dehydration is probably responsible for such symptoms.

There are some patients in whom an alternation of eczema and attacks of bronchitis with asthma may occur. During the eczema, the asthmatic symptoms are entirely wanting, but when the eczema is relieved the pulmonary symptoms rapidly develop.

Eczema of the face is very chronic, easily improved, but cured only with great difficulty. There is a strong tendency to relapse, brought on by neglect of local treatment, by any digestive disturbances, or by overfeeding.

**Diagnosis.**—This rarely offers difficulties. The cases in which allergy is the important factor usually begin on the face. In other locations local causes of irritation are usually apparent. The itching, which is often intense, the presence of eosinophilia, a family history of hypersensitiveness are all helpful points. Sometimes the appearance of the symptoms or their exacerbation can be traced to a change in the diet.

Eczema of the body or extremities may be confounded with scabies or syphilis, and occasionally with other forms of skin disease. Scabies resembles eczema in its intense itching and multiform lesions; but in the former, one may often find evidences of its presence in other members of the family; the parts most frequently affected are the flexures of the wrists, the elbows, the skin between the fingers, the margins of the axillae, the lower part of the abdomen and back, and, in boys, the penis; and by careful examination with a lens some of the characteristic burrows are discovered.

Syphilis is likely to be confounded with papular eczema of the buttocks. The latter affects the parts near the anus, and the irritation may lead to the develop-



ment of spots closely resembling condylomata. In syphilis there is no itching and very little evidence of inflammation; the eruption is copper-colored, and occurs in small circumscribed spots; involvement of the palms and soles should always suggest syphilis. In some instances, however, the local appearances may be indistinguishable from syphilis, and only the presence or absence of other manifestations of that disease will enable one to decide—coryza, enlargement of the spleen, x-ray changes in the bones or serological tests.

The diagnosis from impetigo is easy enough in clear-cut cases, for the patches of uncomplicated impetigo are clearly outlined and discrete. Impetiginous infection of eczematous areas is not uncommon.

Seborrhea, sometimes classified as a form of eczema, is probably a distinct disease; it is described elsewhere. It affects chiefly the scalp, and the greasy nature of the crusted lesions is conspicuous.

**Treatment.**—The treatment of intertrigo and the familiar diaper rash has been discussed elsewhere. In these cases removal of the local irritation is usually all that is required; hypersensitiveness plays little or no part. The more severe forms of eczema affecting the face and body are likely to be very resistant to treatment. Should the simpler forms of local therapy prove unsuccessful one may resort to nonspecific dietary treatment or to specific diagnostic and therapeutic procedures. It may be necessary to employ all the measures intensively before success is attained.

*Local Treatment.*—Irritation of the skin must be avoided as far as possible. The patient should not be exposed to cold and wind; overclothing should also be avoided. Eczematous areas should not be bathed with soap and water; bran baths or oil (cottonseed, corn, or olive oil or liquid petrolatum) should be used for cleansing. Scratching as a result of the severe itching must be prevented, for this interferes with healing and is likely to cause secondary infection. The eczematous areas should be covered by a muslin or linen garment. A mask of this material may be made for the face with openings for the eyes, nose and mouth; sometimes even this will not prevent scratching, and the arms must be restrained by paste-board splints at the elbows, or by bandages.

The procedure which is usually most effective consists first in the removal of scales and crusts. This can, as a rule, be accomplished within twenty-four hours by repeated applications of oil. Some ointment should then be applied, and the parts kept covered with this; it must be applied several times a day. In the presence of secondary infection a 3 to 5 per cent ammoniated mercury ointment may be used. In other instances effective preparations which may be used are: "C.C.Z." ointment,<sup>1</sup> which has distinct antipruritic properties, or some preparation of coal tar. The crude tar must be carefully washed or redistilled to remove irritating materials. This may be made up in a strength of 5 per cent with zinc oxide and petrolatum (the so-called "tar oxide" ointment). An ointment which in our hands

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	Gms. or C.C.	
<sup>1</sup> Calamine .....	2	6
Zinc oxide .....	4	0
Liquefied phenol .....	0	3
Lanolin .....	12	
Petrolatum .....q.s.ad	30	



has sometimes succeeded better than coal tar is given below.<sup>2</sup> Ointments should not be rubbed into the skin, but should be kept in contact with it by means of a mask or dressing. The response to different local applications varies greatly in different cases; some will do better on one ointment, some on another. Antipruritic lotions such as that of calamine and zinc, or black wash have been successfully used. In some cases where there is much exudation dry dressings are advantageous. The area may be covered with a powder consisting of equal parts of boric acid and talcum. Silox, a proprietary preparation of silica gel, is an effective absorbent.

*Nonspecific Dietary Measures.*—Overfeeding should by all means be avoided in eczema, and definite improvement may follow a diminution of the carbohydrate intake, fat being substituted. As already explained this is probably related to the relative dehydration resulting from such a dietary shift. Both these procedures must be used with caution, and the general welfare of the patient should not be lost sight of in an overenthusiastic attempt to improve the skin. The production of dehydration by means of cathartics is not justified, nor should dehydrating procedures ever be carried to the point where clinical symptoms develop.

*Specific Diagnostic and Therapeutic Measures.*—A search for some allergen to which the patient is sensitive is indicated when dealing with eczemas that do not respond readily to local treatment. The general method of procedure is outlined elsewhere, also many of the difficulties and sources of error that may be encountered. Among the common causes of failure to obtain satisfactory results by this approach should be included: (1) failure to continue the search after some one allergen has been incriminated by a skin test. Should the elimination of this reactant fail to cause clinical improvement it may well be that this is not the true offender. (2) The belief that only food allergy can cause eczema; in a definite, though small group of cases inhalants and contactants may be responsible. (3) The failure to use autogenous allergens. The assumption cannot be made that, because the patient fails to react to a commercial preparation of milk protein, milk can be exonerated. A skin test made with the milk the patient is receiving may show a positive reaction, or elimination of this milk may be followed by marked improvement. In such instances the sensitiveness may be due not to the milk protein, but to some extraneous allergen being excreted in the milk. When this offender can be discovered and eliminated from the diet of the cow or the mother, the symptoms may clear up. (4) Lastly should be mentioned the belief, now

		Gms.	C.C.
2	A. {	Stearic Acid .....	40.
		Lanolin (anhydrous) .....	8.
		Liquor carbonis detergens .....	12.
	B. {	Borax .....	0.8
		Potassium carbonate .....	1.6
		Starch .....	2.0
		Distilled water .....	125.
	C. {	"Carbitol" .....	12.
		(Diethylene glycol mono-ethyl ether) .....	
		Rhodinol (or oil of rose) .....	0.5
		Menthol (cryst.) .....	0.2

DIRECTIONS:

1. Melt together stearic acid and lanolin on a water bath, and add liquor carbonis detergens while fats are still warm.
2. Dissolve borax and potassium carbonate in the distilled water; stir in starch and warm this to 90° C.
3. Dissolve the menthol and rhodinol in "Carbitol."
4. Pour A. into B. gradually with constant stirring. Stir mixture vigorously until emulsified. Add C. and stir slowly from time to time until cream begins to set.



rapidly being abandoned, that milk is an indispensable article of diet, and consequent unwillingness to adopt a milk-free diet.<sup>3</sup>

In the early days of skin testing, when specific offending proteins could not be readily discovered, the practice was often recommended of making a radical reduction of all protein food in the hope that the specific excitant could thus be eliminated. This practice is certainly ill-advised, and the same may be said of the policy of removing from the diet all substances to which there is a skin reaction without being certain that they are at fault. We have not infrequently seen eczema commence to improve only after such overzealous dietary proscriptions had been lifted.

A belief, unverified in our experience, is often expressed that orange juice aggravates all cases of eczema. Except in the few cases that are definitely sensitive to this fruit, it should by no means be excluded; we have seen patients develop scurvy even while under medical supervision from such attempts to cure the skin condition.

**Prognosis.**—Many chronic cases of eczema are tedious and respond to therapy only when all available measures are combined. Much depends on the degree of co-operation that can be obtained in carrying out local treatment. Sometimes elimination of an offending protein from the diet causes rapid and dramatic improvement, but more often success is only partial. Fortunately the disease is usually outgrown before the age of three years.

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<sup>3</sup> The following procedures may be used not only in cases of eczema sensitive to cow's milk protein but also in infants who on weaning are found unable to tolerate cow's milk:

1. Cow's milk may be altered by prolonged cooking to such a degree that it may be tolerated. In practically all of these cases the sensitiveness is to the lactalbumin alone and this is denatured by heating. Evaporated milk may meet the demands of the situation. The lactalbumin-sensitive individual will often do very well on preparations of calcium caseinate, since in the preparation of these most of the lactalbumin is removed by washing.

2. The milk of some other animal, such as the goat, may be used.

3. A milk-free diet may be employed. The protein requirements can usually be met by means of egg and various meat preparations; especial care must, however, be taken to prevent mineral and vitamin deficiencies. Calcium in particular is likely to be deficient, and may be conveniently supplied as carbonate or lactate (20 grains or 1.3 gram of the former per day or double this quantity of the latter salt should be sufficient for any growing infant or child). Vegetable proteins, notably soy bean powder, have been used in making milk-free diets. Complete infant foods ("Sobee," etc.) are available in which the mineral deficiencies of such a diet have been remedied. The "almond milk" devised by Moll of Vienna may be useful in this connection. The diagnosis of hypersensitiveness to cow's milk is often incorrectly made at the time of weaning, the symptoms of supposed intolerance being actually due to improper feeding.



## CHAPTER C

### URTICARIA

Typical urticarial wheals may be seen even in young infants. Foods are usually responsible, but a large proportion of the cases result from injectants. The urticaria following the injection of animal serum and that occurring in connection with protein shocks during specific immunization have already been described. Localized urticaria regularly follows the bites of certain insects like the mosquito and the gnat; we have seen generalized urticaria following a bee sting. Urticaria due to inhalants or contactants is comparatively rare; occasionally it results from sensitiveness to some of the common pyogenic bacteria. A number of instances are caused by the administration of drugs.

Urticaria may be associated with any other manifestation of hypersensitiveness, rarely with eczema but not uncommonly with asthma and hay fever. It may accompany various digestive disturbances, such as the abdominal colic of Henoch's purpura; in cases of extreme food sensitivity it may be associated with vomiting. When urticaria is a manifestation of food or drug allergy it usually appears only some hours after the offending material has been ingested. In cases of extreme hypersensitiveness, however, wheals upon the lips and circumoral region may appear almost immediately, usually associated with manifestations of shock. Such extreme hypersensitiveness is usually manifested either towards egg albumin or cow's milk, but we have seen it follow the administration of spinach.

**Lichen Urticatus.**—A more chronic form of urticaria—seen almost exclusively in infants and young children—presents certain features quite different from the ordinary variety. This is due to the fact that papules and vesicles, and occasionally pustules, are associated with the wheals. As the wheals quickly subside, it frequently happens that the other lesions mentioned are the only ones present. This fact has given rise to considerable confusion in names, and the urticaria of infancy has been called *lichen urticatus*, *urticaria papulosa*, *strophulus*, etc. It is now pretty generally agreed that the clinical picture, which is a familiar one, belongs to a single disease, and that this is urticaria.

The initial lesion is the wheal, but on account of the extreme susceptibility of the skin in young children, the process is more intense than in older patients, so that it may result in the formation of an inflammatory papule, which may be topped by a vesicle. In a few hours the wheal may subside, and only the papules or vesicles remain, and without a good history the disease may be a very obscure one. The papules and vesicles occur with greatest frequency upon the hands and feet, the flexor surfaces of the forearms and in the bends of the elbows and knees, but the eruption may be generalized. The palms and soles may be affected.

The more severe form of the disease in poorly nourished children is sometimes accompanied by a pustular eruption, and there may even be deep ulceration



(ecthyma). The usual appearance of the eruption is a number of small inflamed red papules the tops of which are covered with crusts, the result of scratching. It is, as a rule, more severe in regions accessible to scratching. Characteristically, the lesions are small, rarely more than a millimeter in diameter. There is usually severe itching, which leads to loss of sleep, and often in this way the disease affects the general health of the child.

The character of the eruption in urticaria and even its distribution often suggest scabies; and unless one has had an opportunity to witness the development of the lesions, differential diagnosis may be very difficult, as almost every lesion, except the wheal, may be identical in both diseases. Other cases may resemble varicella.

**Angioneurotic Edema.**—In contrast to the infantile form of urticaria, in which the inflammatory reaction is more conspicuous than whealing, is the *giant form of urticaria* in which evidences of inflammation may be inconspicuous, but enormous wheals and edematous areas develop. The lesions usually itch less than the ordinary form of urticaria or lichen urticatus; itching may be absent altogether. Angioneurotic edema shows a predilection for certain sites, such as the eyelid, the side of the face, the tongue or lips, but it may appear upon any part of the body. It is characterized by its asymmetrical distribution and the fact that it shows no tendency to favor dependent parts. Rare instances have been reported in which the condition has affected the larynx with fatal results.

Angioneurotic edema is seen mostly in older children. It is often associated with the common form of urticaria, but may occur independently. It is most frequently caused by foods or injectants. An individual sensitive to fish or some other food may, after eating this for his evening meal, wake up the following morning with an eye completely closed by edema. Unless the excitant is continued the condition rarely lasts more than twenty-four hours.

**Treatment of the Various Forms of Urticaria.**—In the acute cases of ordinary urticaria and angioneurotic edema, such as may be seen after the injection of a substance to which there is extreme hypersensitiveness or after parenteral protein therapy, epinephrine may afford prompt relief. It may be given in doses from 0.2 to 0.4 c.c. of 1:1000 dilution. The effect may last from two or three to twenty-four hours.

Antipruritic lotions are often needed. Calamine lotion or a 5 per cent solution of sodium bicarbonate, ice cold, may give relief; irritating clothing should be avoided. Sedatives are sometimes indicated. At times a mild laxative will shorten an attack of food urticaria.

The discovery of a specific offending substance in ordinary urticaria is often obvious. It may be searched for by the procedures described elsewhere, but for some reason the proportion of these cases in which a positive skin test can be obtained is relatively small, and environmental tests must often be resorted to.

The chronic form, lichen urticatus, is often very refractory to treatment. The discovery of a responsible allergen frequently fails; many cases are complicated by secondary infection and it seems likely that in some of these bacterial allergy plays a part in keeping up the symptoms. The treatment becomes largely sympto-



matic and hygienic—the control of itching, the removal of foci of infection and the general building up of health. A change of climate may prove beneficial. As a rule the condition lasts for weeks or months; occasionally it persists up to the age of three or four years. Subsequently these patients may show a skin which is abnormally sensitive to sunburn, chapping or other irritants.



## CHAPTER CI

### HAY FEVER

Hay fever in children does not differ appreciably from the disease as it occurs in adults. It is uncommon before the age of puberty, but several authentic instances are on record in which the disease has started during the first year of life. Spain and Cooke have called attention to the fact that in nearly all of these cases with an early onset there is a bilateral family history of allergic disease. Among 34 cases reported by them with such a history, more than half started before the age of five years.

**Etiology.**—Practically all cases are due to inhalants; it is questionable if ingestants are ever responsible, though it has been observed that during the hay-fever season administration of a food to which the patient is sensitive will cause an exacerbation of the hay fever. *Seasonal hay fever* is due almost exclusively to pollens. In the eastern United States the pollens of flowers and trees are infrequently responsible; the important groups are the grasses (May through July) and the weeds, chiefly ragweed (latter part of August to early October). *Non-seasonal cases* may be due to animal danders, to cosmetic or insecticide powders. In practically all instances the excitant is air-borne; we have, however, seen one instance in a child in which it was water-borne.<sup>1</sup>

**Symptoms.**—In the seasonal type of hay fever the symptoms are often milder the first year they appear than subsequently. The onset, in any particular season, is usually insidious. The symptoms vary in their intensity with climatic conditions affecting the concentration of pollen in the air. Their subsidence at the close of the season is usually more rapid than the onset. The nose, pharynx and conjunctivae are affected in almost all instances, but not always to an equal degree; sometimes the conjunctivitis is more conspicuous than the rhinopharyngitis. The eustachian tube is often occluded and in the more severe cases nasal breathing may be impossible. A small proportion of hay-fever patients develop eczema as a result of skin contact with the offending pollen. Pollen asthma is not infrequently associated, occurring in about one-third of the cases.

**Diagnosis.**—Seasonal types of hay fever are not difficult to recognize. The nonseasonal ones may readily be mistaken for a common cold. A careful history may reveal their occurrence in a certain locality or a relation to animal contact. The cases due to cosmetic powders may be disclosed by their chronicity. A cold which is not acquired from or conveyed to other members of the household should

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<sup>1</sup>The waters of a lake in which the patient, a boy of twelve, was in the habit of swimming were at a particular season covered with certain algae. When the patient got water in his nose, this would be followed within a half-hour by severe coryza, often sufficient to cause complete obstruction of the nasal passages. The attack would last about an hour. Irrigation of the patient's nose with water from a nearby spring which contained no such algae produced no symptoms. The waters of the lake produced no symptoms in other individuals. The patient had a history of food allergy and asthma as well; some years later he developed ragweed hay fever.



make one suspicious. Rhinorrhea due to sudden thermal changes is occasionally seen in children and may cause diagnostic difficulty. Duke has shown that this condition occurs especially in allergic families and subjects; he regards it as a form of allergy.

Specific diagnostic procedures are discussed elsewhere. In the seasonal type, practically only the pollens need be considered. A knowledge of the flora of the locality and their time of pollination will greatly limit the possibilities and avoid much unnecessary skin testing.

**Treatment.**—The elimination of specific offending substances from the environment is sometimes possible as with sporadic cases due to cosmetics, insect powders, animal danders, etc. It may be practical to avoid ragweed<sup>2</sup> and some other pollens. The tree and grass pollens are less easily avoided than the weeds.

Among the nonspecific measures that may bring relief should be mentioned pollen filters, which may permit sleep at least. Sprays of epinephrine or ephedrine are often of great assistance; sometimes they prove too irritating locally, and in the severest cases these drugs may be totally ineffectual. Diathermy has been used with some success in adults, and it may be that it has a place in the treatment of children as well.

The results of specific treatment are probably not greatly different from those obtained with adults. It seems fair to say that approximately one-third of the cases are greatly benefited, another third slightly benefited and the remainder so little improved that further treatment seems unjustified. Favorable results are reported in which improvement followed treatment for several seasons, though this was not apparent the first year it was used. Insufficient data are available for evaluating accurately the effect of age of onset on the prognosis. An early age of onset does not imply that the disease will be more severe or resistant to treatment. Spontaneous recovery occasionally occurs without explanation, but such a favorable result is not to be expected.

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<sup>2</sup> Maps showing the geographical distribution of this and other pollens are available.



## CHAPTER CII

### ASTHMA

Asthma is a disease characterized by attacks of paroxysmal dyspnea with evidences of diffuse obstruction of the finer air passages throughout both lungs. Writers differ greatly in their statements in regard to its frequency in early life, mainly because of lack of agreement as to what shall be included under this term. During the first few years of life attacks of bronchitis are often accompanied by wheezy respirations and the physical signs characteristic of asthma. This tendency is seen especially during the first year, and is usually outgrown gradually in the preschool period. Attacks of this kind are often spoken of as "asthmatic bronchitis" or "spasmodic bronchitis." They differ from asthma in being continuous rather than paroxysmal, in the constant presence of a local infection and in the failure to respond satisfactorily to epinephrine. Allergy seems to play little part in their production; specific sensitiveness cannot be demonstrated, nor is there eosinophilia. Such attacks are analogous to the spasmodic croup of infants, which shows a similar age incidence. Their relation to asthma is doubtful and they are therefore not included in the ensuing discussion. One sometimes sees patients who have had spasmodic bronchitis in infancy who later develop allergic manifestations; sometimes these attacks gradually merge into true asthma. Whether such observations are entirely dependent upon coincidence cannot be definitely stated.

**Incidence.**—The condition is of common occurrence, being noted in approximately 1 out of every 150 children admitted to the Harriet Lane Home in Baltimore. About one-quarter of the cases occurring in the first decade develop during the latter part of the first year; the majority have declared themselves before the age of five. Even in cases which may be definitely allergic to pollens or danders, the asthma may first manifest itself after some infection—particularly after pertussis. During the first decade boys appear to be affected about twice as often as girls, a sex predisposition which does not hold in later life.

A positive family history of some allergic disease can be obtained in 50 to 75 per cent of patients. If the parents are skin-tested, the percentage of cases in which a hereditary basis can be demonstrated rises to 80 per cent or more.

**Pathogenesis.**—That asthma is, in the great majority of instances, an allergic manifestation has been very well established since Meltzer first made this suggestion in 1910. Specific hypersensitiveness can be demonstrated by cutaneous or environmental tests in fully 80 per cent of asthmatic children; somewhat less frequently is this true of adolescents and adults. Of the nonreactors, focal infection often appears to be responsible, for the symptoms may subside when foci are cleared up. Such foci may be in the tonsils, adenoids or other lymphoid tissues, or in the teeth. Paranasal sinusitis is often responsible. The discovery and removal



of any cause of chronic nasal infection—such as a deflected septum, a polyp or a foreign body—may bring prompt relief from asthma. Asthma associated with focal infection can rarely be attributed to bacterial allergy; at least, skin sensitiveness to the ordinary pyogenic bacteria is rarely demonstrable. More often the asthma appears to be of reflex origin. Sluder was able to cure attacks in some patients by cocainizing the vidian nerve or the sphenopalatine ganglion. There can be little doubt that in such cases the asthma is of neurogenic origin; in the usual variety it is attributed to direct excitation of the bronchial end organ.

In regard to the immediate cause of the bronchial obstruction three factors have been incriminated: (1) plugging of the bronchi with a peculiar type of viscid secretion; (2) edema of the bronchial walls, and (3) spasm of the bronchial musculature. The relative importance of these three factors is still disputed. In mild attacks plugging of the bronchi with secretion seems to be the most important factor; by gentle coughing the patient can clear his tubes, relieving his dyspnea and causing disappearance of the wheezy respiration for some minutes, until the secretion reaccumulates. The secretion so coughed up consists chiefly of very tenacious mucus; it may come up in small, glairy globules (pearls of Laënnec) or in longer cylindrical casts of the smaller bronchioles (Curschmann's spirals). A similar state—in which the dyspnea can be relieved by coughing up these plugs—may be seen at the onset or defervescence of a severe attack, but at its height no such relief is possible, no sputum being brought up; edema and muscle spasm seem to close the tubes effectively. The relief of such dyspnea by epinephrine is attributed to vasoconstriction with consequent limitation of edema and secretion, by those who stress the importance of these factors, while those who emphasize the importance of spasm attribute the action of the drug to stimulation of sympathetic bronchodilator fibers.

The few postmortem observations made in acute cases have revealed either nothing at all or some thickening of the subepithelial tissue of the bronchial wall, including the muscle. In chronic asthma interstitial changes and emphysema may be found in variable degree. Bronchoscopic observations during acute attacks have revealed congestion and edema of the bronchial walls; viscid mucus plugs have also been seen *in situ*.

*Nonspecific Predisposing Factors.*—In an asthmatic individual any local irritant may bring on an attack—an acute bronchial infection, the inhalation of smoke or irritants like sulphur dioxide gas, which may be met with in railway tunnels, or even cold air. Any violent exertion which gets the patient out of breath may do this—even a paroxysm of laughter. Psychic factors are thought to precipitate asthmatic attacks at times. Not infrequently the attack follows an unusually heavy meal.

The great majority of asthmatic attacks occur at night, a fact which cannot as a rule be attributed to concentration of allergen in the bedroom. Many theories have been advanced to explain this, the most plausible being that epinephrine in the blood is then at a low ebb, since demands for the mobilization of blood sugar are then at a minimum.

**Symptoms.**—A patient suffering from a severe attack of asthma presents a very striking picture. There is marked dyspnea, sometimes orthopnea; there may be



pallor, cyanosis or profuse perspiration. Except in infants, in whom the breathing is likely to be rapid, the rate is as a rule slower than normal. Both inspiration and expiration are labored and accompanied by wheezing sounds which can be heard at a distance. There is usually a frequent, unproductive cough. The accessory muscles of respiration are called into action, but in spite of this the excursion of the chest is very limited; the lungs remain more or less constantly expanded. During inspiration retraction of the soft parts of the chest wall may be seen as in laryngeal stenosis; in expiration the apices are often puffed out in the supra-clavicular fossae. The chest is hyperresonant to percussion and the lung bases are depressed posteriorly. On auscultation breath sounds are obscured almost completely by sibilant râles; the expiratory phase is prolonged.

The onset of such an attack is often sudden; the patient may wake up at night with the attack at its height. Even in the daytime it may not take more than a minute or two to send a patient with normal respiration into an extreme state of dyspnea. In other instances it may come on more gradually, passing through the mild stage. Subsidence is usually gradual, a severe attack passing into the mild stage in which the bronchial tubes can be cleared and the typical sputum brought up. The attack may terminate spontaneously within a quarter of an hour, or it may last for hours or days unless arrested by treatment. Attacks may occur at frequent intervals, several times a day and night.

Other allergic manifestations, notably urticaria, may be associated with the attack. When the asthma is due to food allergy there may be coincident digestive symptoms. Pollen asthma is often associated with hay fever; mild asthmatic symptoms may occur at night only at the height of the hay-fever season. There is, however, no constant relation between the coryza and bronchial symptoms in a pollen-sensitive individual; mild symptoms of coryza may usher in a severe asthmatic attack, or coryza may be absent altogether.

*Laboratory Findings.*—The sputum is of little assistance in diagnosis and is readily obtainable only in older children. Charcot-Leyden crystals, Curschmann's spirals, pearls of Laënnec and eosinophils are the characteristic features, but none of these are pathognomonic, nor are they constantly found. When present together they are highly suggestive of asthma. Eosinophilia in the blood (more than 4 per cent) is found in roughly two-thirds of the cases, and when present is of diagnostic significance. In a series of cases examined in one of our clinics by Wile the average was 10.7 per cent, the highest being 26 per cent. The eosinophilia is sometimes greatest just after an attack but often it remains unchanged. Eosinophils in the sputum run fairly parallel to their number in the blood.

**Complications and Sequelae.**—After repeated attacks alterations at the hilum of the lungs are likely to be found. An x-ray of the chest in a chronic asthmatic usually shows increased density of the root shadows, probably due to thickening of the bronchial walls. Chronic emphysema sometimes develops in a surprisingly short time, and may be extreme. Serious thoracic deformity may result. On account of the loss of sleep and interference with nutrition, growth and general health may be seriously affected. Puberty may be delayed. We have seen permanent stunting of growth in a woman whose asthma ceased to be severe at about fifteen years of age.



**Diagnosis.**—The characteristic features of asthma are its paroxysmal nature, the typical wheezing sounds in the chest, the absence of fever except in those types associated with infection, and the allergic nature of most cases as shown by the history, eosinophilia and demonstration of specific sensitiveness. In differential diagnosis one must consider the possibility of pharyngeal or laryngeal obstruction, which should not be difficult to eliminate. A foreign body impacted in the bronchial tree should be thought of if a severe attack with wheezing occurs in an individual not known to be subject to asthma.

“Asthmatic bronchitis” and the “capillary bronchitis” type of pneumonia may produce similar signs, but are distinguished by the fever, the nonparoxysmal character of the symptoms and the absence of allergy; epinephrine gives little or no relief. Other entities to be considered are the rare asthmatic attacks occurring with enlarged thymus in the newly born and asthma associated with enlarged tuberculous mediastinal lymph nodes.

*The Specific Diagnosis.*—All cases of asthma should be investigated from this point of view, according to the principles discussed elsewhere. Food allergens should be suspected if the patient is very young and especially if digestive symptoms accompany the attack. Inhalants should be suspected in older children and in cases where coryza is associated with the attack. Pollens are easily detected by the seasonal incidence of symptoms, but sensitiveness to the epidermal proteins, house dust, and other excitants may require considerable testing to discover; to locate the offending substance in the child's environment may be even more difficult.

A number of instances of “epidemic asthma” have been reported, which have been traced to industrial plants in a particular locality giving off some unusual form of dust—a flour mill, castor oil factory, etc.

With nonreactors to the more common excitants, one should search for possible foci of infection, such as have been mentioned. Hypersensitiveness to nonantigens usually fails to give skin reactions. Many drugs fall into this class—particularly aspirin and the various coal tar products. Asthma associated with respiratory infections not infrequently proves to be due to some drug given at that time.

**Prognosis.**—In general the younger the child the more favorable the prognosis. This is probably because sensitiveness to food allergens, which is responsible for many early cases, tends to disappear spontaneously. Even when food sensitivity does not subside alone, the chance of desensitization with most of the members of this group is good. One's prognosis should, however, be guarded, for food sensitivity may disappear only to be followed by inhalant or some other form of hypersensitiveness and the asthmatic attacks return. With sensitivity to inhalants the prognosis is good if these can be discovered and eliminated. Some success may follow specific therapy. Sensitivity may be outgrown; a large number of cases subside gradually at about the time of puberty.

The prognosis in the cases attributable to infection must be guarded. Successful removal of foci is not always possible. Cases associated with chronic pneumonia are distinctly unfavorable.

Even moderately severe chest deformities associated with recurrent asthma may eventually disappear if the attacks are controlled, particularly if this is effected before the age of puberty.



**Treatment of the Attack.**—*Epinephrine* given intramuscularly usually gives immediate though often only temporary relief. The dose for a child of three years is 0.2 to 0.4 c.c. (℥ iii to ℥ vi) of a 1:1000 dilution; this may be repeated hourly if necessary. If it is frequently used a tolerance develops and larger quantities must be given. It is more effective if given early in the mild stage; in the more severe paroxysms it may fail altogether. A sustained effect of similar physiological nature may be obtained with *ephedrine* given by mouth in doses of 5 to 10 milligrams (gr. 1/12-1/6). Young patients are less prone than adults to experience disagreeable symptoms with either of these drugs. Many individuals obtain prompt relief from various proprietary asthma powders which are burned and the fumes inhaled; most of these contain *stramonium leaves*. Atropine given by mouth or injection is without benefit. *Cocaine* sprays of the throat and *opiates* will relieve asthmatic attacks. Their habit-forming qualities contraindicate their routine use. Occasionally extremely severe paroxysms are met with, which are refractory to all other drugs, and at such times morphine or cocaine locally may be used.

Restriction of diet and catharsis may be of some supplementary value during an attack; heavy eating is certainly to be avoided.

**Treatment between Attacks.**—The most important part of therapy is the discovery and elimination of the specific agent responsible for the attack. Food allergens are easily removed from the diet, as are many of the epidermal and other miscellaneous excitants from the environment. In pollen asthma flight is preferable to active warfare; a change of residence may keep the patient free. Immunization should be attempted if avoidance of contact is impossible or, fairly tried, is unsuccessful. Pollen filters may bring nocturnal relief.

Nonspecific measures that may be of some help are (1) avoidance of the various nonspecific precipitating causes of asthmatic attacks, (2) dehydrating diets and (3) nonspecific immunization procedures. Every means should be sought of promoting the patient's general health. Even in those whose asthma is due to specific excitants, foci of infection should be removed whenever possible. In the cases of bacterial allergy and nonspecific cases this sometimes results in a cure. In refractory and chronic cases the patient should be taken to some place where his attacks are less frequent, and kept there in the hope of breaking up the tendency to recurrence. This may require several years. The region best suited to most asthmatics is one which is high, dry and moderately warm. The best places in this country are New Mexico, Arizona and Southern California. Some children do well at the seashore; others much better in the mountains. Patients often suffer less in cities than in the country.

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## SECTION XVI

### *FUNCTIONAL NERVOUS DISORDERS*

#### CHAPTER CIII

##### BEHAVIOR PROBLEMS

The behavior problems of childhood are among the most frequent conditions with which the physician has to deal. Many pediatric practitioners estimate that these constitute at least 50 per cent of their clinical problems. The prevention of these disorders, proper child training, is primarily a function of the educator and the parent. It is only after they have failed in some respect that the physician is called in to correct the difficulty and to prevent its recurrence in the future. With the great majority of these minor problems the pediatrician should be able to deal himself. The more difficult ones and the major psychoses belong rather to the domain of the psychiatrist.

We do not propose to enter into the argument as to whether heredity or environment is the more important etiological factor. Unquestionably many instances can be attributed directly either to faulty heredity or faulty environment alone; in an even larger number both are at fault, instability in the parents being reflected in the environment of the child as well. The behaviorist school of psychologists would attribute nearly all phenomena of behavior to the environment. Watson, working with small infants, was able to demonstrate only a small number of responses which could be regarded as instinctive and hereditary, such as objection to painful stimuli, to loud noises and to the feeling of sudden loss of support. The conclusion was drawn that all other responses were the result of conditioning—of associations developing from the individual's past experience. The fallacy in this view lies in the assumption that all inherited characteristics manifest themselves at birth. To ignore the possibilities of postnatal mental development along an inherited pattern is like attributing the maturation of the sex organs at puberty to the sex environment in early life. Nevertheless, the behaviorist philosophy has been of great value in the encouragement it has given to parents and educators, for it is only by means of the environment that behavior can be influenced.

It is not possible to draw a sharp distinction between neuroses of inherited and of acquired origin. An abnormal child in a normal environment may develop a condition identical with that seen in a normal child subjected to a bad environment. The picture of the constitutionally neuropathic child is, however, a fairly characteristic one. In infancy environmental factors play little part, but in older children the picture is usually the result of a combination of inherited and environmental factors; most of these children, in addition to having an unstable nervous constitution, have been badly handled as well.



### THE NEUROPATHIC CHILD

The neuropathic child may give evidences of his peculiar constitution during infancy, or sometimes not until he is several years of age.

Even in the first weeks of life the condition may reveal itself in an unusually early reaction to sights and sounds. Infants may fix their attention upon people and objects as early as the third or fourth week. They are readily startled and terrified by things to which the normal infant pays no attention. Spells of prolonged crying occur, usually suggesting intestinal colic. At other times the condition manifests itself in a tendency to tonic muscular spasm; there may be opisthotonos, flexion of arms and legs, clenching of hands, increased reflexes, all strongly suggesting a cerebral condition, and these symptoms may persist for many weeks. Such an infant is often spoken of as a "hypertonic" infant. These patients are usually wakeful, taking less sleep than the average infant of the same age. They fall asleep with difficulty and are aroused by the slightest noise.

There are two symptoms which are especially likely to attract attention in early infancy: vomiting and diarrhea. The vomiting is usually characterized by the fact that it takes place very readily without any apparent discomfort and that the simplest forms of food and even water may be vomited. Vomiting may develop without sufficient cause and the usual symptoms ordinarily associated with it are entirely absent. Frequently the food is simply regurgitated into the mouth, where it may be held and swallowed again or it may run out at the corners of the mouth. Most cases of rumination are to be classed as evidence of a constitutional peculiarity.

The vomiting may be only occasional with no interference with weight and growth, or it may be so severe as to cause a marked loss of weight and even threaten life. It sometimes ceases spontaneously; at other times it may be most obstinate. The diarrhea also varies in severity. It may occur with breast-fed as well as artificially fed infants. The stools may be only slightly more frequent than normal, three to five a day, and well digested; or they may be much more numerous and passed through the intestinal tract so rapidly that they are undigested and often contain mucus.

The diarrhea is apparently caused by an excessive irritability of the intestines, an increased reaction of the nerves to the stimuli which ordinarily produce moderate peristalsis. As a result, the food is hurried along more or less unchanged, together with increased intestinal secretions. The diarrhea may be most obstinate. Marked and even serious malnutrition may result.

The gain in weight may be slow even without vomiting or diarrhea. Many of these patients require an extraordinarily large intake of food in comparison with others of the same weight before they will commence to gain. Part of this excessive requirement seems to be passed unabsorbed, part of it is consumed in muscular work. The musculature is usually strong, but there is little subcutaneous fat. In addition to the digestive symptoms mentioned, breath-holding spells may be observed. Other neuroses are seen only after infancy. Neurotic traits are more common in girls than in boys; they are seen especially in the Jewish and Latin races.

After the period of infancy, a greater variety of manifestations may occur;



nearly every system in the body may be involved. The symptoms relate not only to the nervous system but to the physical condition of the child as well. Neurotic children are almost always poorly nourished. They have labile vasomotor systems and for that reason blush readily and very often have cold hands and feet. The pulse is apt to be rapid and undergoes a marked increase in rapidity after slight exertion, or as the result of the slightest nervous impression. These children are usually anemic; their appetite is poor and they often suffer habitually from constipation, which is usually of the spastic type. It is not infrequent, however, for diarrhea to occur, particularly as the result of excitement. Cardiac palpitation is frequently complained of. Nervous vomiting is seen with children, girls especially, of the school age. It occurs in the morning immediately after breakfast, is accomplished without effort and there is usually no nausea. The appetite may remain fair and there is no vomiting at any other time. Nocturnal enuresis is found with many neurotic patients, and masturbation is not infrequent even in those of two or three years. All sorts of habit spasm are of frequent occurrence. Any of the neuroses mentioned in the succeeding pages may occur.

Mentally, neuropathic children are apt to be bright, often precocious, but they usually show a great lack of concentration. They are frequently animated and talk rapidly, oftentimes stammering. They are never quiet, are full of restless energy, changing rapidly from one occupation to another, but soon tire and complain of fatigue. Emotionally they are sensitive and mercurial, passing rapidly from crying to laughing. With strangers and under unfamiliar surroundings they may become morose and negativistic. Headache is frequent and often persistent. Vague pains in almost every situation are complained of. Some of these children are confirmed hypochondriacs. Many are affectionate and attractive, but they are usually self-willed and often tyrannize over the household.

Sleep is usually poor. Such children have great difficulty in going to sleep and occasionally have night terrors. In general, nervous children demonstrate a combination of irritability to all impressions with a ready exhaustion. Untreated, they are apt to grow up into nervous, often hypochondriacal adults. Even with the greatest care and wisest treatment it is a long and tedious process to bring about an approach to the normal.

**Environmental Factors.**—The constant association with a nervous adult will do much to develop neurotic traits in a child. A faulty mode of living, late hours with inadequate sleep, occasionally disease, are contributory factors. In the great majority of instances, however, the important cause is one of two things—neglect or overattention in the home. The neglected child often craves attention; he may be jealous of another member of the family—usually a younger brother or sister. The neurosis or neurotic traits develop as a method of attracting the parents' attention. There may be open hostility to the child in the home, and he undertakes antisocial behavior out of revenge. The child who suffers from overattention is often an only child; he may be receiving the undivided attention of mother or nurse. Often he is too carefully protected from outside contacts with other children. Behavior difficulties are particularly common in children of parents who fear behavior difficulties, who talk a great deal about them and who suggest them to their children by threatening what will happen if they don't behave properly. They



occur frequently in socially self-conscious families, where there is an abnormally great desire to do the right thing, and to be known to have proper behavior. A source of difficulty quite as potent as the morally overambitious parent is the parent who is intellectually overambitious for the child. Overstimulation, particularly the attempt to make a prodigy out of an average child, is responsible for much unnecessary distress and many behavior problems.

**Recognition and Treatment.**—The recognition of many of these functional conditions may be obvious enough; on the other hand, it may be extremely difficult to rule out organic disease; this may require a most exhaustive study of the patient. Once it is decided that the difficulty is functional, the problem of its cause still remains—to what extent the child or the environment is at fault, and what factor or factors in the environment. Often only a prolonged observation and study of the home conditions will enable one to decide.

Treatment of neurotic disorders consists largely in the wise management of daily life. It is sometimes advantageous to remove the child entirely from the environment in which he has been living. It is a striking fact how infrequently neurotic disorders are seen in hospital practice. Here a child encounters an atmosphere, often for the first time in his life, where certain things are expected of him as a matter of course, and with the example of others following a given routine compliance soon follows. If a child is removed from his home the person in charge should be one who will not spoil or indulge him and will bring about a proper regimen with a gentle but firm control. The physical welfare of the child should by no means be neglected.

Nervous children are much benefited by association with normal children of their own age. No greater mistake can be made than to keep such a child by himself for a prolonged period, but it must be remembered that he is usually unable to bear either the physical or the mental strain to which normal children are subjected. For that reason the periods both of study and play should be short. Education at home is usually undesirable; but school hours must be carefully adjusted to the child's endurance. He should not be allowed to become either physically or mentally exhausted. Frequent short periods of rest are necessary. Particularly to be avoided are such things as motoring, children's parties, theaters, moving picture shows, and the incessant use of phonograph and radio. Altogether the most satisfactory way of bringing up such a child is in the country away from the excitement and distractions of city life. Unfortunately, this is not always possible.

In addition to looking after the physical welfare and general hygiene of the child an adjustment is often necessary in the family and perhaps in school as well. One should attempt to determine whether the family attitude is one of overindulgence, of overambition, of neglect or open hostility. A maladjustment at school is the cause of many difficulties.

Although attempts have been made to resolve specific behavior difficulties by scientific methods, little progress has been made in this direction.<sup>1</sup> Psychoanalysis

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<sup>1</sup> The study of conditioned reflexes commenced by Pavlov early in this century promises to throw some light on the mechanism of behavior disorders. An unconditioned reflex is a subcortical response; for example, the flow of saliva following the introduction of food into the mouth. However, by a process of association it is possible to obtain this same response from some other selected stimulus. For example, if a bell is rung and a few seconds later food put in the mouth and this process is frequently repeated, even-



has its enthusiastic advocates for childhood as well as adult problems, notably Anna Freud, but we are inclined to doubt that its possibilities are other than very limited. Like other cults, when used inadvisedly it may do harm. On the whole it must be admitted that our approach to these behavior problems is still largely intuitive. A child's point of view is quite different from an adult's. He is a more emotional being. One must bear in mind his love of independence, of power, of affection and praise, his easily aroused jealousy, his fear of condemnation, ostracism, inadequacy. Certain individuals—unfortunately neither all physicians nor all parents—have an innate gift for understanding a child's point of view.

## REFERENCES

See references on page 796.

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tually the secretion of saliva can be produced by ringing the bell alone. This response is a *conditioned reflex* and the stimulus (the bell) is spoken of as the *conditioned stimulus*. The principles of conditioning have been understood and used by animal trainers and educators long before they were expressed in scientific terms. Education itself is nothing but a process of conditioning; the conditioned response may be a positive one or an inhibition. Pavlov and his followers have gathered a great deal of information in regard to the optimum time intervals for conditioning, the effect of multiple stimuli, the specificity of stimuli, the duration and the inhibition of such reflexes, etc. The work is of interest to educators and may at some future date supplant the empirical procedures by which advances in educational methods have in the past been made.

Of particular interest are the responses obtained when conflicting stimuli or stimuli differing slightly from the conditioned stimulus are applied. In animals this may be followed by: (1) feeble or absent response, or (2) inhibition of a more general type—even a sort of dazed state may be produced, or (3) various “neurotic” symptoms may appear, such as tremor, irritability, strongly negativistic or even maniacal behavior. Behavior problems can be regarded as the effect of unwise, inaccurate and conflicting conditioning. Here again, however, the scientific experiment has added little to what had been learned empirically. The effects of mental conflict are familiar enough. But it is possible that in the future the experimental method may outrun the empirical one and lead the way in knowledge of the prevention of neurotic disorders.

Two practical applications of the conditioned reflex may, however, be mentioned. The rapidity with which a conditioned reflex can be established in a child is a rapid and convenient method of standardizing at least one important attribute—teachability. In cretins and other mental defectives the time required to establish such reflexes is very much prolonged. Secondly, Aldrich has used the conditioned reflex as a diagnostic method for determining the integrity of the sense organs in cases of suspected deafness. In an infant who failed to respond to auditory stimuli, he was able to establish a conditioned reflex with an auditory stimulus, proving that hearing was present. By ringing a bell and subsequently pricking the skin to cause crying, he eventually was able to produce crying by the sound of the bell alone.



## CHAPTER CIV

### NEUROSES

#### NEUROSES OF THE ALIMENTARY TRACT

**Anorexia.**—The management of cases of poor appetite has been discussed elsewhere. Nearly always this comes from forcing food, as a result of which the child is never allowed to get really hungry. Occasionally loss of appetite is due to the fact that the child has been repeatedly punished at meals. He develops an unpleasant association and consequently a distaste for meals altogether.

**Neurotic Vomiting.**—This is more common in older children, but may be met with even in young infants.<sup>1</sup>

*Rumination* should also be mentioned as an alimentary neurosis that is seen in infancy. It has been discussed elsewhere. Rumination in infancy does not seem to be a precursor of that rather rare neurosis—rumination of adults. The process is essentially different. The infant ruminator apparently obtains pleasure from being able to regurgitate his food but he ejects it as soon as it is brought up to the mouth, whereas the adult ruminator, like the ruminant animal, chews his food for some time after it is brought up and swallows it again.

**Pica (Perverted Appetite).**—Many children, especially between the ages of two and six years, develop abnormal tastes and cravings for articles usually considered inedible. They may eat dirt, sand, mortar, bits of wood or coal; sometimes they will eat the bed linen, wool plucked from blankets or their own hair. They may eat the paint from toys or furniture. The cause of this habit is obscure. It is seen in mentally defective children, but is by no means confined to them. Some of these patients exhibit other neurotic manifestations. Gastric disturbances seem to play a part in a certain number of instances. Pica is a common symptom of infection with hookworm. In many instances the habit is innocuous, but it may give rise to serious disturbances. The eating of paint is a common cause of lead poisoning. Hair when eaten in large quantities may cause intestinal obstruction or may give rise to a "hair-ball" tumor in the stomach. In other instances the digestion may suffer from the presence of much indigestible material. Unless checked the habit may continue for many years. A close observation of the child is usually necessary to break the habit. Younger children may require restraint; with older ones diversion and moral suasion may be effective.

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<sup>1</sup> J. C., an only child, had been brought up in a household where she was continually spoiled and overstimulated. At the age of five months she began to vomit, at first only in small amounts and only when excited by visitors, but later much more frequently. She seldom vomited after supper and had never been seen to ruminate. Various dietary measures had failed entirely to control the vomiting. Physical examination, including x-rays of the gastro-intestinal tract, were entirely negative. The patient exhibited a violent temper. She would burst out crying when left alone. She often chewed the bed clothes and the bed.

She was admitted to the hospital at the age of nine and one-half months. No special therapeutic measures were applied. On the second day after admission she vomited only once—when the mother came to visit her. She remained in the hospital a week and was discharged with improvement in disposition and cure of vomiting.



**Thumb-sucking.**—The instinct of a young infant to put objects into his mouth, and the presence of the sucking reflex, often develops thumb-sucking or finger-sucking as a habit. Nearly all infants will suck the fingers when hungry; this cannot be considered abnormal, but an effort should always be made to stop it. Unless broken early it may persist throughout infancy and sometimes much longer—even up to the age of puberty. The longer the habit has lasted, the more difficult it is to break.

The results of sucking may be somewhat serious. Deformities of the thumb or finger, of the lips and teeth and even of the jaw may be produced. It was once taught that thumb-sucking tended to develop the habit of masturbation, but this seems more than doubtful.

During the first two years of life mechanical restraint is usually successful in breaking the habit. Pasteboard splints may be applied to the elbows, preventing flexion of the forearms without interference with the use of the hands. Other effective methods are the use of metal cuffs enclosing the hands, or better yet the use of mittens. Sometimes the application of adhesive tape to the offending finger is all that is required. With older children such methods are not effective; moreover, restraint may be harmful. It is better to divert the patient, to rely on suasion, to offer rewards, and to appeal to pride.

**Nail-biting (Onychophagia).**—This habit is easily acquired in older children. It is best controlled by rewards and by keeping the nails cut extremely short.

## NEUROSES OF THE RESPIRATORY TRACT

The commonest form of respiratory neurosis seen in early life is *breath-holding spells*. They are seen most frequently in the latter part of the first and during the second year, but beginning in infancy they may recur from time to time until the age of four or five years. Several attacks may occur in a day or they may occur at intervals of several days or weeks. In susceptible children almost any form of excitement may precipitate one; by far the most frequent causes are temper and fright. If anything is attempted to which the child objects—a cold bath, inspection of the throat, or taking away a toy—an attack may ensue. The child's face becomes flushed, then livid; there is general rigidity followed by relaxation and loss of consciousness. The entire attack usually lasts about half a minute. The child then gets up and is as well as ever.

Although there are instances on record in which such attacks have terminated fatally, respiration not being renewed, the condition is ordinarily a benign one and need occasion no concern. It must be carefully differentiated from tetany, with which it was long confused. A crowing sound and the presence of clonic convulsions are presumptive evidence of tetany; other confirmatory evidence should be sought. The management of these attacks is much the same as that of temper tantrums. They should be ignored, or should be treated by dashing cold water on the child's face. The child should not be allowed the satisfaction of occasioning concern, which is in many instances the underlying motive for the attacks.

Other respiratory manifestations of neurotic disorders are rare. In older children one occasionally sees attacks of paroxysmal dyspnea as manifestations of hysteria.



## NEUROSES OF THE CIRCULATORY SYSTEM

These have already been referred to. One may find a great many vasomotor symptoms such as are found in hyperthyroidism—flushing, cold hands and feet, a labile pulse—profuse perspiration, or headaches. Or, one may encounter the so-called “irritable heart” (*neurocirculatory asthenia*) in which slight exertion may produce cardiac palpitation, perspiration and symptoms of exhaustion.

## NEUROSES OF THE LOCOMOTOR SYSTEM

**Tic (Habit Spasm).**—This is a form of spasmodic motor response which often originates in a purposeful voluntary or reflex act, but persists until it becomes habitual and is almost entirely involuntary. The movements are more common in the face, but may affect any part of the body. Sometimes some local irritation starts the process, such as an uncomfortable collar which may give rise to shrugging of the shoulders or twisting of the neck. Blinking may start in the course of a conjunctivitis and persist after this has disappeared. Sometimes the habit originates in imitation of an adult, as in the case of certain facial grimaces. Clearing of the throat, a dry cough or sighing are other forms. Often a child will show two or three tics simultaneously; he will blink one eye, screw up the corner of his mouth, twist his head to one side and shrug his shoulders.

The only condition with which habit spasm is likely to be confused is chorea. In both conditions the movements disappear during sleep and are exaggerated by nervous excitement and fatigue. The important differential points are the purposeful character of a tic and the fact that it is repeated with great exactness time after time. Tics are often associated with other functional nervous conditions.

Treatment should be commenced as soon as possible, for it is very difficult to eradicate habits that have become well fixed and almost entirely involuntary. Careful attention must be given to general hygiene, particularly to the avoidance of fatigue and overstimulation. Many city children recover when sent to the country. Any local cause which can be discovered should be removed. Little is to be gained by nagging and punishments, which usually only aggravate the condition; far more by rewards and encouragement.

Sometimes a tic improves when a coexisting neurotic symptom is successfully treated:

B. S., six years of age, had had a facial tic for several months. It appeared only when he was with his father. The latter was a nervous, high-strung person, the governess even more so. There was an associated anorexia. The latter symptom, though of minor importance in the parents' eyes, was treated first; with cessation of all coaxing and threats at meal times, the boy went on a hunger-strike for forty-eight hours. Following this, his appetite promptly returned, he ate normally without urging, and the tic simultaneously disappeared.

**Screaming Tic with Echolalia or Coprolalia.**—This dramatic disorder, first described by Gilles de La Tourette, is occasionally met with in older children. In the midst of an ordinary conversation the patient suddenly and without warning may scream out several words, usually expletives; there may be associated minor tics such as turning the head or shrugging the shoulders. A few seconds



later the conversation is continued as if nothing had occurred. Such outbreaks may occur in the middle of a sentence. Sometimes they are repeated every few minutes.

The disorder is a very contagious one. Such patients should be isolated, for there is a great tendency for others who hear it frequently to imitate it. The roots of the difficulty can usually be traced to some preceding psychic trauma or repression. Its proper handling will usually require the services of a psychiatrist.

**Nodding Spasm.**—This strange disorder, first described by Henoch, is in no sense a habit spasm. It involves a triad of symptoms: a tendency to intermittent rhythmic nodding or twisting of the head; intermittent nystagmus; and an inclination to gaze at objects out of the corners of the eyes, with the head partly flexed. The last named feature is less constant than the other two. It is found most often between the ages of six and eighteen months. There is no particular sex incidence. The condition is, however, distinctly more common during the winter months. In our experience it has been more common in Negroes.

The etiology is unknown. The seasonal incidence has suggested a relationship to poor illumination, as in miner's nystagmus. The majority of patients are rachitic, but this may well be a coincidence; the same may be said of difficult dentition as a cause. It is possible that it represents some benign infection of the nervous system. Typical cases have been observed in adults.

The motions of the head are in some cases up-and-down, in others side-to-side, and in others a sort of combination of the two. The rate of movement varies from 60 to 120 nods per minute. A series of nods usually lasts but a few seconds, but it may be continued for long periods. Nodding of this form is seldom seen when the child is in a horizontal position. It is brought out by holding him in a sitting position. Spells may be to some extent prevented by distraction.

The associated nystagmus is usually far more marked in one eye than in the other. The amplitude of oscillations is small and the rate is usually, but not invariably, rapid. It may be lateral, vertical, or rotatory; hippus is occasionally associated. The nystagmus not infrequently precedes the onset of head-nodding by a few weeks. Unlike the latter symptom, it occurs both when the patient is lying down and when he is sitting up. Cases have been reported in which the nystagmus appeared without the head nodding, but this is rare.

The condition is self-limited, disappearing spontaneously after a few months. It is rarely seen after the second year. Beyond the interest which attaches to the diagnosis, it is of no clinical importance.

**Hiccup.**—This is due to spasm of the diaphragm; it is especially common in young infants. In most cases it is due to some irritation in the stomach or esophagus; it is seen after eating and may depend upon overdistention with food, air swallowing, etc. In other instances it is found in perfectly healthy infants and has no relation to the taking of food. In general peritonitis and with intestinal obstruction, hiccuping may be continuous and very distressing. In older children hiccup sometimes occurs as a pure neurosis.

Treatment should be directed to the cause. In infants the expulsion of gas may be facilitated by manipulation or position. When it is a nervous symptom only it may be arrested in older children by holding the breath, by prolonged forced expiration as in blowing a trumpet, sometimes by a few swallows of water.



**Head-banging.**—This is a habit occasionally seen in infants or young children. The head is struck rhythmically against the mattress, the sides of the bed, the wall or any other convenient place, and this may be kept up for two or three hours. The habit may be practiced during the day or before going to sleep at night. Head-banging is rarely a symptom of brain disease. It may be seen in mentally deficient infants but is by no means a sign of backwardness. In the great majority of cases it does not indicate any nervous derangement whatever, although it may be annoying for adults to watch. It is caused by an impulse similar to that which leads other children to scratch their faces, pull their hair, etc.; they actually seem to derive pleasure from it. Some instinct demanding rhythm is probably satisfied; the satisfaction is perhaps akin to that which certain adults derive from rocking in a chair. Head-bangers rarely traumatize themselves; if a pin or a sharp object is placed back of the head, the banging ceases as soon as the pain is felt. The habit gradually disappears spontaneously, being rarely observed after the fourth year. It can be broken by any one with sufficient time and patience, who stops the child whenever he commences it. Children who bang their heads up and down against the mattress are much discouraged if the mattress is placed upon the floor.

Head-banging of the type described should not be confused with that seen in a temper tantrum. Here a child in a fit of rage may knock his head against the wall and may do considerable injury. Such tantrums are often accompanied by breath-holding spells. The treatment in such cases is to ignore the patient's bid for attention.

**Head-rolling.**—Here the patient lies on his back and rolls the head from side to side. The condition has the same significance as head-banging and clears up spontaneously at about the same time. Its disappearance can be accelerated by training the patient to sleep on his stomach.

**Hysterical Motor Disorders.**—These are discussed in connection with hysteria.

## DISORDERS OF SLEEP

**Disturbed Sleep, Sleeplessness.**—Disturbed or restless sleep is much more common in infancy and childhood than is true insomnia, although the causes of the two conditions may be the same.

In infancy these symptoms are most frequently due to hunger or to indigestion resulting from overfeeding or improper feeding. Very often disturbed sleep is the result of bad habits, such as rocking during sleep or night-feeding. Sometimes it arises from pain of colic or otitis, rarely from dentition; at other times it may be simply the expression of a condition of extreme nervous irritability, the result of inheritance or of the child's surroundings. It is often caused by the persistent activities of a fussy nurse or mother.

In later childhood the first thing to be suspected when sleep is much disturbed is some derangement of the digestive organs; in this will be found the explanation of fully half the cases. Other cases are due to obstructed respiration from adenoid growths of the pharynx or enlarged tonsils, sometimes to nocturnal attacks of asthma. A lack of fresh air in the sleeping room, excessive or insufficient bedclothing, and cold feet, are other frequent causes. Disturbed sleep with "start-



ing pains" is one of the earliest symptoms of tuberculosis of the hip. Prolonged insomnia is not uncommon after epidemic encephalitis. In the nervous exhaustion resulting from overpressure in schools, and in malnutrition and anemia, disturbances of sleep are well-nigh constant. They are also seen in organic cardiac disease and in all pulmonary conditions accompanied by dyspnea or cough. Sleep may be disturbed in consequence of bad dreams which have their origin in exciting stories heard or read just before bedtime, or in too violent or exciting play. To discover the cause in almost any case it is necessary to investigate carefully the whole routine of the child's life.

The condition may be one of real insomnia which may last for weeks or months; or the sleep may be simply disturbed and restless, the child waking many times during the night; when asleep he will not lie quietly, but constantly changes his position. Sometimes children wake suddenly with a scream, but immediately drop off to sleep again.

The essential treatment consists in the discovery and removal of the cause of the disturbance. This will often involve a radical change in the manner of feeding, in the hygiene of the nursery, and in all the surroundings of the child. A change of nurses sometimes results in a speedy cure. In no circumstances should the physician countenance the use of sedatives, except in the case of acute disease. Nostrums for "teething" and "pacifiers" should be forbidden. Many mothers and nurses fall into the habit of using them, because the injurious effects are not appreciated. When the cause of sleeplessness is found and removed the child will sleep. If food, diet, and all bad habits have been corrected, nervous causes should be investigated. When no cause can be discovered the treatment should consist in putting the child upon the simplest possible diet, and in attention to the general health. In many cases a warm bath at bedtime will be found beneficial. A quiet, darkened room, plenty of fresh air, and the stopping of both eating and drinking during the night, are essential.

**Night-terrors (Pavor Nocturnus).**—Two classes of cases have been grouped under this head, both having this in common, that sleep is disturbed by fright. The distinction between them is not altogether a sharp one. *Nightmare* may be due to partial asphyxia from adenoids or to other causes mentioned under disturbed sleep, or it may be gastric or intestinal in its origin. These cases are quite frequent. Sleep may be disturbed from the outset, and the attack may be merely the culmination of such disturbance. The child wakes in a state of fright and excitement, but soon becomes oriented, realizing that he has had a bad dream. He recognizes those about him, but it may be a long time before he is sufficiently calm to sleep again. The attack may be remembered perfectly the next day. Cases like this are to be managed in the same general way as those of disturbed sleep above mentioned. Nightmares occur particularly in neurotic children and in the subjects of chronic fatigue. The cause is sometimes referable to an emotional disturbance. Some patients have them for days or weeks following the administration of an anesthetic. In others they follow episodes of excitement—birthday parties, movies, tales of adventure told at bedtime.

In the second group are the only cases to which the term *night-terrors* should really be applied. These are relatively rare, but the condition is a more serious



one, and indicates instability of the nervous system. Such attacks are often seen in children who subsequently develop a neurosis. They may be the precursors of migraine or epilepsy. In a small proportion of cases they constitute epileptic equivalents. The attack usually comes suddenly where a child has previously been sleeping quietly, and more frequently in the early part of the night than later. He is generally found sitting upright in his bed in a bewilderment of terror, being "afraid of the dog," or "the bear," or there is some other vision or hallucination which has produced the fright. Often this is associated with something of a red color. The child does not recognize those about him, does not know where he is, and may go to sleep again without coming to full consciousness. The next day there is no recollection of what has happened. The attacks may be repeated at intervals of a few months, or they may occur every few nights; but whatever the peculiar nature of the vision, it is likely to be repeated in nearly the same form.

All mental and nervous strain should be most carefully avoided, and when the attacks are frequent sedatives should be given at bedtime. Some person should sleep in the same room with the child, or in an adjoining one with the door open. Some cases associated with indigestion, resulting from too heavy a supper or an unwise choice of foods, respond readily to simple dietetic measures. We have seen some patients benefited by the administration of 10 or 15 grams of glucose just before bedtime.

**Excessive Sleep, Narcolepsy.**—It is rare that either infants or children sleep an unnatural amount of the time unless one of two causes is present—organic brain disease, most frequently tuberculous meningitis, or the use of drugs. In certain individuals, however, there is seen a tendency to fall asleep which does not depend on intercurrent disease of the brain, nor yet upon drugs. It is not progressive, and may continue for years, perhaps throughout life. This condition is known as "narcolepsy." There seems to be little doubt that this depends on some cerebral lesion, but its nature and location is not well known and is probably inconstant. In one case seen in Baltimore, which was operated upon, a large aberrant cerebral vein was found. Ephedrine has been found useful in symptomatic therapy.

## OTHER NEUROSES

**Enuresis.**—This has been discussed elsewhere. It may be due to organic causes or may be a purely functional condition, due to bad training. It may also be a neurosis, representing a desire on the child's part to attract attention. Several factors may play a part in any given case. Often it is necessary to concentrate all one's therapeutic measures in order to control it.

**Outbursts of Temper.**—These take different forms at different ages. In infancy there may be abnormal crying, unwillingness to go to sleep, or breath-holding spells. In older children, in addition to demonstrations of temper such as an adult may show, one occasionally encounters episodes of a more dramatic nature such as fainting spells and pseudoconvulsions. At any age these constitute a strong bid on the part of the child for special attention, and it is often a problem to decide whether such attention is deserved. Excessive crying is a not uncommon complaint in infancy, particularly at night. The physician's duty is to rule out



organic causes of pain and, this done, to stand firmly by a policy of deliberate neglect. There is a common but unfounded superstition that an infant may, through excessive crying, develop a hernia or bring on convulsions. It is usually more effectual simply to ignore the patient and let him cry it out than to attempt to overcome the outburst by punishment. In the case of breath-holding spells, however, which usually appear in children from one to three years of age in whom there is a large element of deliberate calculation, quicker results are often obtained with swift punishment such as throwing cold water on the face. Many cases of pseudoconvulsions in older children originate in the imitation of an actual convulsion which has been seen and the power of which in attracting attention and devotion is obvious. Most of these children will abandon the habit at once when it is explained to them that their motives are understood.

**Anxiety Attacks.**—These are not so very rare in children. In some instances the anxiety attack comes on without apparent cause. Such attacks are often brief. In other instances there has been some predisposing cause, for example fear of a dog following some unpleasant experience. In the latter instance the situation can be met by encouraging pleasant associations with dogs. The attacks coming on spontaneously are of more serious import; they indicate a definite instability of the nervous system. Harsh disciplinary measures should be avoided; it is far better to manage them sympathetically.

**Behavior Difficulties Associated with Mental Defect.**—Mental defects belong more properly to the organic nervous diseases. They are mentioned in the present connection only because the mental defect in mild cases is often unrecognized and it is the resulting behavior problems that attract attention. Many individuals with subnormal mental equipment go through life without causing difficulty. In a proper environment they learn to do routine tasks and can often eventually support themselves without being a burden on the community. Others who are less fortunately situated are unable to adapt themselves in their social relations, and fail in their intellectual pursuits. Failure in school often leads to truancy, and the resulting punishments may cause resentment and antisocial behavior. Such individuals may be made a butt of in school or may be exploited by more intelligent but unscrupulous companions. A large proportion of criminals are recruited from this class of the population. There may be abnormal emotional behavior. Some individuals are hyperkinetic and unable to concentrate; others are sullen and morose and exhibit cruelty, or perhaps morbid sexual traits.

The early recognition of mental deficiency is a matter of the greatest importance, for in many instances antisocial behavior can be prevented if the child is put in the proper environment. As is stressed elsewhere, these children must have tasks suited to their ability and must not be judged by normal standards. The more marked cases of defect will require institutional care, but others can learn to do manual labor and many mechanical tasks. Life in the country offers fewer hazards to these individuals than city life.

## REFERENCES

See references on page 796.



## CHAPTER CV

### HYSTERIA

Hysteria is a condition developing in more or less psychopathic personalities in which repressed complexes assert themselves in a form simulating organic disease. Many of the conditions already described are in reality manifestations of hysteria—such as neurotic vomiting, “irritable heart” and probably breath-holding spells. The tics and various bad habits are, however, essentially different processes. In the latter conditions the patient is entirely conscious of what he is doing and obeys a strong, often a compelling impulse, and by doing so he obtains a conscious satisfaction. In hysteria, on the other hand, the patient is self-deceived. He is unconscious of the origin of the disorder and believes himself the victim of organic disease.

**Etiology.**—Hysteria is very rare before the seventh or eighth year. As to sex, there is no such predominance of females as in later life, although even in childhood they are more frequently affected than males. It is seen in children who inherit a nervous constitution. Contributory factors are those mentioned in the discussion of neuropathic children. It may follow any of the acute infectious diseases; or it may be excited by injury, fright, or imitation.

**Symptoms.**—There is scarcely any disease in which the clinical picture presented is so varied as in hysteria. It may simulate almost any form of organic disease of the brain, lungs, digestive organs, bones, or joints. The symptoms are seen in almost every conceivable combination.

Psychic symptoms frequently predominate. There may be periods of mental depression, a change in disposition, an indifference to surroundings, a capricious humor, or a nervous condition of extreme irritability with irregular paroxysms of laughter or weeping without cause. There may be great excitability of temper, and fits of passion almost maniacal in their severity. There may be various delusions.

Sleep is frequently disturbed, sometimes somnambulism is present. There is often a disposition to deception about the most trivial matters, which may last for weeks. There is a tendency to imitate the symptoms of various diseases, which the patients may have witnessed in others or about which they have read. Sometimes the special senses are affected, giving rise to hysterical blindness or deafness, usually of short duration.

Sensory symptoms are the most frequent manifestations of hysteria in early life. There is often general or local hyperesthesia, which may be so great as to simulate inflammation of the various internal organs. Anesthesia is much less common, and is usually associated with paralyses. In such circumstances it is apt to involve the whole of one or more extremities and in such a way as to be inexplicable by any organic lesion. The anesthesia usually disappears during sleep,



at which time a painful stimulus will arouse the patient. Paralysis is an infrequent but striking symptom. There may be monoplegia or paraplegia, more rarely hemiplegia, or paralysis of all four extremities. There may even be edema and a certain degree of atrophy of the affected extremity from disuse. The inability to stand or walk, though the legs can be moved perfectly in the recumbent position, is observed at times. Headache is an occasional symptom, and is sometimes associated with great tenderness of the scalp.

Joint symptoms are not uncommon, and are often most puzzling. All forms of organic disease of these joints may be simulated. Joint symptoms are usually seen between the ages of ten and fourteen years, and occur in both sexes. There may be lameness referred to one of the large joints, curvature of the spine, or torticollis. The symptoms are most frequently referred to the hip or the knee. There is a marked hyperesthesia of the whole limb, and sometimes of the body. The resistance and pain caused by passive motion are often greater than in most joints which are the seat of organic disease. The deformity may be very slight from spasm of the flexors only, or it may be severe, and followed by contracture, so that the thighs may be flexed tightly against the abdomen with the heels against the buttocks. Such deformities may last for months. There may be considerable muscular atrophy, but only that which comes from disuse. A special difficulty in diagnosis arises from the circumstance that these symptoms occasionally follow an injury.

Organic disease of bones and joints may usually be excluded by attention to the following points: The mode of onset is more abrupt than is seen in bone diseases, and the course of the disease is quite irregular. The degree of deformity is greater than is seen in bone disease of the same duration. There is general hyperesthesia of the limb, tenderness of the spine upon pressure, and undue sensitiveness to heat or cold. The deformity varies from time to time, being always more marked when examination is attempted. If the patients are closely watched, other evidences of hysteria may be seen. Under complete anesthesia the contractures disappear entirely. There is no enlargement of the articular ends of the bones, no swelling of the soft parts, and no evidence of active inflammation or of supuration. Under proper treatment there is in most cases perfect recovery, often in a surprisingly short time.

Digestive symptoms are quite frequent. There may be loss of appetite, at times so extreme as to lead to great emaciation. Dysphagia from spasm of the esophagus, or regurgitation of food on attempts at swallowing are sometimes seen. There may be troublesome hiccup. Vomiting is a frequent symptom. It is seldom severe. A very frequent form met with is that which occurs in school children before starting for school. Throughout the rest of the day nothing is vomited and the appetite may be good. Persistent diarrhea, constipation, meteorism, and incontinence of feces may occur.

In the milder forms of hysteria there are seen many varieties of tonic or clonic spasm. There may be local spasm of the eyes, face, or mouth, spasm of the muscles of the neck producing torticollis, or the muscles of respiration causing dyspnea, which may be constant or paroxysmal. Disturbances of speech are quite common, especially in older children. There may be inability to speak above a whisper, while



the voice is retained in singing or after the application of the faradic current to the neck. Stuttering and stammering may be due to hysteria. Very rarely no attempt at phonation can be made. A common symptom is hysterical cough, which may be so frequent and so severe that grave disease of the lungs is suspected; the chest, however, is free from the physical signs of disease. In more severe cases the symptoms of chorea major and attacks of hystero-epilepsy may appear. The latter are rare in children and do not differ essentially from such attacks in older patients. There are usually prodromal symptoms. The convulsive movements are exceedingly varied in type. There are painful sensations and sensitive areas, by pressure upon which hysterical symptoms may be increased or even convulsions excited. The respiration may be rapid or irregular. All variations in tonic and clonic spasms may be seen. Opisthotonos is frequent. Consciousness is not fully lost, but is disturbed, and hallucinations are present. The temperature is normal. Important features which serve to distinguish these attacks from epilepsy are the fact that hysterical attacks come on only when the patient is being observed, and that no bodily injury is suffered.

Other symptoms occasionally seen in hysteria are polyuria, very frequent urination, sometimes incontinence of urine, and disturbance of the secretion of saliva or perspiration.

The general condition of hysterical patients is usually below the normal. They are poorly nourished and anemic; they sleep badly; they have capricious appetites and feeble digestion.

**Diagnosis.**—Hysteria is apt to be overlooked because its occurrence in children is not considered as often as it should be. In most cases the diagnosis is easy if hysteria is suspected. Much importance is to be attached to a family history of neurotic disorders or psychoses. A combination of vague disconnected symptoms is usually present which admits of no other explanation. Organic disease can be excluded only by careful and repeated examinations. The use of the conditioned reflex (see page 762) may be valuable in determining whether or not an organic lesion involving a sense organ is present. It is to be borne in mind, however, that hysteria not infrequently occurs as a complication of some organic or constitutional disease.

**Prognosis.**—This is better than in adults, especially if the cases are taken in hand early, before the disease has become deeply seated. Much depends on the skill with which treatment is carried out. The outlook is less favorable when the hereditary tendency is strongly marked. In many cases there are relapses later in life.

**Treatment.**—The general measures recommended for the care and readjustment of neuropathic children are applicable here. An analysis of the home or school situation will often give one a clue as to the origin of the disorder—the situation from which the child wishes to escape. Often when the matter is explained to him the condition clears up at once. Resistance may, however, be encountered, and in such cases discipline may be effective. The child should be put to bed, no books or toys allowed and no effort made toward his amusement. No sympathy should be exhibited but the child should be treated with kindness and firmness. This moral treatment is quite as important as any other part of the therapeutics. In



cases with hysterical joint symptoms suggestive treatment by electrical apparatus of various kinds is often of distinct benefit. In no circumstances should mechanical force be used to overcome deformity.

The following history illustrates several manifestations of hysteria:

Margaret H. (H.L.H. 40914) was first seen at the age of thirteen years. She had a family history in which shiftlessness, alcoholism and various sex offenses occurred abundantly on both sides of the family. The father was alcoholic and shiftless; the mother was unstable and neglectful. Four daughters, including Margaret, were all bed-wetters. At the age of eleven the patient fell on the back of her head and acted dazed for a few hours without losing consciousness. A year later she had another fall, after which her right knee was put in a cast for some time. Thereafter she had numerous spells in which the right knee "gave way" and she fell. For a year preceding her first visit to the dispensary she suffered from attacks of pain in her eyes associated with dimness of vision. At night she was sometimes unable to close her eyes, but was relieved at once by rose water placed in the eyes by her stepfather. One night she woke up suddenly and complained that she could not close the eyes without pain. Her first outspoken visual disorder occurred when she was in school. The teacher was reading a story and from time to time would ask questions. Margaret was afraid she would be asked. She felt sick, complained of pain in the eyes and could not see at all. She was then sent home. These spells of temporary blindness came on about every other month, whenever she was confronted with school difficulties. They always resulted in her being sent home or being allowed to rest in the nurse's room. The most recent attack was accompanied by paresthesia. According to the patient's description it felt "as if someone were trying to knock my eyes out way back there, and then they got blurry." Shortly after this, the fingers of the left hand became numb and the sensation spread through the entire arm; she was nauseated at lunch. Because of this illness the patient was taken home and did not have to work out problems; vision soon returned and the numbness cleared up within a few hours.

On examination the patient was found to be ten pounds underweight and to have a mental age of not quite twelve years (I.Q. 85).

Treatment consisted of measures to improve the patient's nutrition, in making an adjustment at school and in explaining the origin of the attacks to the family and to the patient herself. She was put into a special class, since it was clear that she was being forced beyond her intellectual ability; subsequently she was transferred to a vocational school. The rose water treatment of the eyes was discontinued and it was explained that no organic disease was present and that the attacks were the result of an unconscious attempt to escape from a difficult situation.

The patient was followed for many months thereafter, and no further attacks occurred.

#### REFERENCES

See references on page 796.



## CHAPTER CVI

### DISORDERS OF SPEECH

The most common functional speech defects are stuttering, stammering, lispings, idiolalia, delayed speech, and functional aphasia. All forms are much more frequent in boys than in girls, the proportion being more than four to one.

**Stuttering.**—This is the most frequent form of speech disturbance. Articulation is distinct and the separate sounds are properly produced, but there is a difficulty in connecting the consonant with the succeeding vowel; this seems like an obstacle to be overcome. Occasional stuttering is seen in very many children; indeed it is easily brought out by excitement in individuals of any age. It is more frequent in the third and fourth years, before speech is thoroughly mastered, and is usually a temporary condition, lasting for a few weeks or months. We have seen a number of cases similar to the following: A little boy became very anemic, slept poorly, and suffered from malnutrition as a result of the confinement incident to a home in the city. He soon began to stutter, and in a short time it became painfully marked. After a few weeks in the country he improved very much in his general condition, gained four or five pounds in weight, and his stuttering completely disappeared. In other cases stuttering follows some acute illness, and under such conditions also it is usually of short duration.

Most children who become habitual stutterers do not begin until they are six or seven years old, and sometimes even later. Stuttering may arise from imitation, and inheritance is an important etiological factor.

It is important that all such cases receive early treatment before the habit becomes firmly fixed. The prognosis is good for spontaneous recovery in nearly all the cases seen in very young children, and also in those coming on after acute illness. Other cases in which the condition has become habitual should have the benefit of systematic training in a special school or under a competent teacher in breathing and vocal gymnastics.

**Stammering.**—This term is sometimes used synonymously with stuttering. Kussmaul makes the distinction between them that, in stammering, individual sounds are difficult of production, while in stuttering it is syllabic combinations. Stammering is the more conspicuous of the two; the patient may stick fast at a word or a syllable for several seconds, becoming more tense the more he struggles, until finally it is blurted out with unnatural violence; or he may monotonously repeat a syllable half a dozen times, unable to go on to the next. Even in the most severe cases the patient may be able to sing or to recite from memory with no difficulty whatever. Most children who become habitual stammerers do not begin until they are six or seven years old, and sometimes even later.

The mechanisms underlying neuropsychic blocking of this kind are still but imperfectly understood. Stammering sometimes develops in instances when too



forcible attempts have been made to convert a left-handed subject to right-handedness.<sup>1</sup> It has been suggested that stammering invariably reflects an uncertainty of the normal dominance of one cerebral hemisphere over the other. It is not infrequently accompanied by other symptoms of nervous instability, such as tics and enuresis. All cases should receive early treatment, before the habit becomes firmly fixed; this consists in careful training combined with regulation of hygiene, especially of mental hygiene.

**Lisping.**—In this condition there is an imperfect production of certain sounds, which may be so marked that speech is almost unintelligible. This condition may depend upon some defect of the organs of articulation, or it may be a purely functional condition dependent on habit. In the latter group the commonest form is that in which sibilants are pronounced “th.” The treatment is educational.

**Idiolalia.**—This is a rather uncommon condition seen in only children and in families where children have been unduly segregated and not allowed to play with others. A form of speech develops which is comprehensible to the group alone but not to the uninitiated. In the case of an only child the parents can understand the child’s speech, but have often become so accustomed to it that they do not realize that it is abnormal. The treatment is association with other children.

**Delayed Speech.**—This may depend on a cerebral lesion, causing mental defect. It may also depend upon deafness. In other instances it is a purely functional condition. Speech may be late in consequence of prolonged or severe illness, and when once acquired it may be lost from similar causes. Although the normal child of two years will as a rule put words together in short sentences, there are exceptions to this. We have seen a number of children who did not speak at all at the age of three, and yet subsequently developed in a perfectly normal manner. We know of one such child who was unquestionably bright and could make all his wants easily understood by means of signs; he obviously had not felt the need for speech. When those about him feigned ignorance of what he was attempting to convey by signs speech developed very promptly.

**Functional Aphasia.**—Temporary loss of speech sometimes follows infectious diseases, notably typhoid fever. We have seen the diagnosis of typhoid made from this symptom alone. A child was admitted to the hospital with aphasia which had followed a recent febrile illness of unknown nature. Because of the aphasia a Widal reaction was done and found to be strongly positive. Aphasia is not uncommon in the more severe attacks of chorea, particularly when there is considerable muscle weakness. The condition is usually transient, lasting but a few days and clearing up as the chorea subsides. Exceptionally, however, it may be quite prolonged. West records an instance in which speech was recovered only in the course of nine months. For a long time the child could say only “yes” and “no.” Aphasia of this kind is quite distinct from the more frequent type in which speech is abundant but not easily understood, due to the muscular incoördination accompanying chorea.

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<sup>1</sup> One should never attempt to convert a left-handed subject to right-handedness by forcible means such as tying the left arm. This may give rise to various neurotic disorders. A left-handed subject can be taught to eat with the right hand if this is done by gentle persuasion, and no untoward results follow. It is unwise to attempt to make him write with the right hand.



Functional aphasia is to be distinguished from failure of speech in acute illness due to prostration, and also from local injury or peripheral nerve paralysis affecting the organs of speech.

The following case is an example of functional aphasia occurring in the course of rheumatic chorea:

V.B. (B.H. 68963), eight years of age, was admitted to the hospital for active chorea associated with a flare-up of rheumatic carditis. His first rheumatic manifestations occurred at four years of age, beginning as arthritis and continuing as chorea and carditis for several months, so that he was left with signs of mitral stenosis and insufficiency. His functional recovery, however, was complete; he went to school and took part in games like a normal child, during a free interval of more than three years.

The second attack of rheumatic activity, for which he was admitted, was preceded by an upper respiratory infection. Choreic movements recurred, of greater intensity than before; he had fever up to 101° or 102° F. each day, the heart showed signs of active carditis in addition to those of the older valvular lesions, and he developed successive crops of subcutaneous nodules. In time the choreic movements were to some extent replaced by great muscular weakness. About five weeks after the commencement of the attack, the patient suddenly ceased speaking. He could still phonate, and cried loudly if hurt; and he appeared to be mentally alert and to desire to speak. It was not possible to test his ability to write. He appeared to understand what was said to him.

The aphasia continued unchanged for ten weeks, when he suddenly found himself able to say "yes" and "no," and within another thirty-six hours he talked quite normally. The return of speech was associated with a conspicuous improvement in the choreic movements and weakness of the muscles of the right arm and leg. The patient gave a perfectly lucid description of his sensations during the aphasia; he "wanted to talk, but couldn't."

#### REFERENCES

See references on page 796.



## CHAPTER CVII

### MASTURBATION

This is not uncommon even in infancy. We have observed many cases during the first year, and some as early as the seventh or eighth month. It is seen in children of all ages and in both sexes; but in infants and very young children it is, in our experience, much more common in girls.

Local causes are present in many cases. The most frequent are long or adherent prepuce, phimosis, balanitis, vulvovaginitis, eczema of the labia, threadworms, and tight clothing. Any irritation may lead the child to rub the parts in some way, and a pleasurable sensation being excited, this action is repeated until a habit is formed. After infancy the habit of masturbation may be acquired from other children, and is sometimes taught by vicious nurses. In older children, however, it usually results from self-exploration, which is simply a phase of normal psychological development.

Mere handling of the genitalia should not be regarded as masturbation; the term should be limited to those cases where this is carried to the point of inducing a pleasurable sensation. Erections can be brought about, even in early infancy, but before the onset of puberty orgasm does not occur.

The habit is common in mentally defective children, but it is in no sense to be regarded as a sign of backwardness or psychopathic personality. It often accompanies endocrine dyscrasias associated with precocious sexual development.

In infants and very young children masturbation is usually accomplished by thigh friction or by rubbing the body against a pillow, a chair, a pole or some other object. The variety of ways is almost endless. Frequently the child will simply sit with the thighs crossed and rigidly held, and sway the body backward and forward. This may last for some minutes and be accompanied by flushing of the face and some appearance of excitement. It frequently happens with little children that these "queer tricks," as they are often regarded, have been continued for months before their true nature is suspected.

Infants and young children may practice the habit openly, but often a consciousness that they are doing something wrong leads even young children to seek seclusion when they repeat the habit. It is especially likely to be practiced when children lie long awake alone after they go to bed, or if they wake early. The habit is always made worse by any deterioration of the general health. We have known many children, who were thought to be entirely cured, to relapse under such conditions.

Masturbation may be practiced only occasionally or with great frequency. Some girls of only seven or eight years may have fairly regular periods in which masturbation is practiced. In one of our patients such periods for a considerable time occurred monthly. During them even very little girls may lose all sense of



modesty and become nymphomaniac. In the intervals such children may be perfectly normal. Masturbation is very contagious. Even little children of eight or nine years may disseminate the habit throughout a group of playmates or even an entire school.

In regard to the consequences of masturbation widely different views have been held. It was long believed that persistent masturbation led to mental deficiency, insanity, epilepsy, hysteria and a variety of other neuroses. There can be no doubt that defectives commonly practice the habit and that it is more common in neurotic individuals; such traits are to be regarded as the cause rather than the result of the habit. Most of the neuroses that have developed in masturbators have been the result of unwise treatment that has been employed in the past. When masturbation is made a moral issue or when it is depicted as something that will lead to imbecility, this may cause great mental distress in a sensitive impressionable child who has been unable to control the habit; the seeds of a neurosis are all present. Particularly harmful are many of the pamphlets circulated in schools in which masturbation is referred to as "self abuse." In China, where masturbation has been encouraged in boys with a view to accelerating the development of the sex organs, the reputed mental consequences have not been conspicuous. The most that can be said in regard to the consequences of masturbation is that, if practiced frequently, it is likely to lead to an undue amount of time being spent in sex pre-occupations, as a result of which the various somatic activities of life may suffer.

In the treatment, local causes must be removed as far as possible. Pinworms should receive appropriate treatment. Attention should be paid to cleanliness of the genitalia and the clearing up of local inflammations. In boys circumcision may be recommended if there is phimosis or a redundant prepuce; even without these it has proved of benefit by suggestion. In girls vulvovaginitis should be treated if present. Breaking up adhesions about the clitoris, or even circumcision or cauterization of the clitoris have all been tried, but as a rule which has exceptions these measures accomplish little. Care should be taken that the clothing does not irritate the parts.

In young infants much may be accomplished by mechanical restraint. The kind of restraint which is necessary will depend upon the manner of masturbating. If by the hands, they should be tied during sleep, so that the child cannot reach the genitals. If by thigh-friction, the thighs should be separated by tying one to either side of the crib; in inveterate cases a double side-splint, such as is used in fractures of the femur, may be applied.

In children who are over three years old such contrivances are almost invariably unsuccessful. Distraction and education are much more important. Corporal punishment is of little or no benefit and may even do harm by encouraging deception and lying. A parent or some other intimate person—preferably not more than one—should secure the child's confidence and seek to develop his self-control. The appeal should be made on aesthetic rather than on moral grounds. Masturbation should not be painted as a shameful thing, but as a physiological process to be brought under control just as the excreta are brought under control. Sometimes it is advisable to separate a child from companions who may be vicious. The possibility that the patient may teach the habit to others must also be kept in mind. At



times absence from home under the care of a trustworthy companion is essential to successful treatment. We have seen some obstinate cases cured by hypnosis.

General hygiene is of great importance. An abundance of outdoor exercise should be encouraged. Almost any exercise except horseback riding may be recommended.

The prognosis is usually good except in children who are psychopathic or defective. The longer the habit has been practiced, however, the more difficult it is to cure. On this account its early recognition is of particular importance. Long-standing cases are most difficult and most discouraging for the physician.

#### REFERENCES

See references on page 796.



## CHAPTER CVIII

### HEADACHES

Headaches are not common in little children except in connection with disease of the brain or meninges; in older children they occur from causes similar to those seen in adult life. The most frequent headaches may be grouped in the following classes:

1. *Toxic Headaches*.—Such are the headaches resulting from nephritis, and those seen at the beginning and in the course of many acute infectious diseases. A large number of toxic headaches are associated with disturbances of digestion.

2. *Headaches of Functional Nervous Origin*.—These usually occur in children who are neurotic, either from inheritance or surroundings. They are most frequently seen in girls from ten to fourteen years old. Some are intellectually bright, and have been crowded in their school work; others are dull and learn only with difficulty, and in consequence worry over their work until their health becomes undermined. A familiar example is the Monday morning headache of the child who does not wish to go to school.

3. *Headaches from Organic Nervous Disease*.—Under this heading may be mentioned those due to cerebral tumor, to syphilitic processes, or in fact to any organic disease of the brain. True facial neuralgia is rare in childhood. A common cause of facial pain is caries of the teeth.

4. *Migraine*.—This is a rare cause of headache in children. Among 70,000 admissions to the Harriet Lane Home in Baltimore, 13 instances have been observed, the youngest being only three years of age. The manifestations do not differ from the disease as seen in adults.

5. *Headaches due to Disease of some of the Organs of Special Sense*.—In connection with the eyes there may be errors of refraction, conjunctivitis, keratitis, iritis, or strabismus; connected with the nose there may be polypi, hypertrophic rhinitis, adenoids or disease of the accessory nasal sinuses; connected with the ears there may be otitis or foreign bodies in the canal. Each one of these conditions requires special treatment.

6. *Disturbances of the genital tract* are rarely a cause of headaches in children, although this may be the case in girls about the time of puberty, especially when menstruation is delayed or difficult.

**Diagnosis.**—The discovery of the cause is often difficult. In a young child, organic disease of the nervous system should always be suspected. In older children the most frequent causes are digestive disturbances, nervous exhaustion, malnutrition, and visual disorders. A study of the urine should not be omitted.

**Treatment.**—The only successful treatment is that which is directed toward removal of the cause. For symptomatic relief, cold to the head, a hot foot bath, and aspirin are useful.



## CHAPTER CIX

### CONVULSIONS

Under the head of convulsions are included attacks of acute transient nervous disturbance, characterized by involuntary rhythmical spasm of the muscles, either of the face, trunk, or extremities, or all of them, usually accompanied by loss of consciousness. They may be regarded as "motor discharges" from the cortex of the brain.

All young children, but especially infants, are extremely prone to convulsive disorders. In certain infants, especially those who are rachitic, this susceptibility is much heightened.

**Etiology.**—Etiologically, convulsions may be divided into those of organic and those of functional origin, according to whether a pathological lesion of the central nervous system is or is not demonstrable. It must not be overlooked, however, that what we now consider functional may, with improved methods, be shown to depend upon an actual change in the tissues of the brain. Under the head of organic, or those due to direct irritation of the cortex of the brain, may be included all convulsions occurring with the various forms of cerebral disease. The most frequent are meningitis, meningeal or cerebral hemorrhage, tumor, abscess, encephalitis, hydrocephalus, embolism, and thrombosis. Developmental defects of the brain, especially microcephalus, are frequently the cause of repeated convulsions that are usually classed under epilepsy. Convulsions due to organic disease may be found at any time during infancy and childhood. Because of their dependence upon traumatism at birth they are frequent in the first few weeks of life.

Convulsions of functional origin are more frequent during the latter half of the first year and during the second year than at any other age. Many of these are due to tetany, either active or latent. It has been held that the most important predisposing cause of convulsions in infancy is the instability of the nerve centers, which is dependent upon a lack of development of the voluntary centers of the cortex. It should be emphasized, however, that while convulsions of functional origin are exceedingly common in infancy, they are not so in the first three or four months of life when instability of the centers might be assumed to be the greatest. Convulsions are very frequent at the onset of certain diseases, particularly pneumonia, scarlet fever, malaria and acute nutritional disorders. They may be regarded as the counterpart of the chill which ushers in a severe acute infection in adults. Occasionally even a mild infection, such as acute pharyngitis or acute cervical lymphadenitis, may be prefaced by a severe generalized convulsion.

It has long been held that convulsions were caused by materials absorbed from the gastro-intestinal tract. It is certainly true that overfeeding or indigestion may excite convulsions. In many cases these children are suffering from tetany, and it



is very likely that the convulsions frequently are not due to any specificity of the material absorbed, but that any irritation to the child's nervous system is likely to be followed by convulsions. Convulsions of this kind are sometimes seen, it must be admitted, in infants and in older children when no evidence of organic disease can be detected, nor any symptoms of tetany and no hyperexcitability of the nervous system as shown by electrical examination. The cause of these is not clear.

Convulsions are apparently at times of toxic origin. They may result from conditions like uremia, asphyxia, and the encephalopathy associated with lead poisoning; here there may well be an organic disturbance of the nature of edema or congestion. In pertussis, which, of all the infectious diseases, is the one in which convulsions are most frequent, several factors may be present: gastric tetany from repeated vomiting with significant loss of acid gastric secretion, asphyxia due to a severe paroxysm, or in some cases an organic lesion such as cerebral hemorrhage or encephalitis.

The interesting observation has been made by Josephs that some young children who suffer from one or more attacks of convulsions may have a low sugar concentration (0.04 to 0.06 per cent) in the blood during and immediately following the convulsions. This suggests that the convulsions are the direct result of hypoglycemia and are analogous to those that occur from an excess of insulin. These children are usually suffering from fever due to some infection and as a result have refused food for a number of hours; they can often be shown to have an easily exhaustible mechanism for maintaining the blood sugar level during starvation. Several of the children observed have had convulsions with each infection and have shown no evidence of tetany or any disease of the nervous system.

Convulsions ending fatally may be seen without obvious explanation. "Status lymphaticus" was formerly supposed to account for the fatal outcome, but it must be admitted that the cause of death is altogether obscure. In such instances MacLean and Sullivan demonstrated a low level of spinal fluid sugar, whereas in the ordinary type of convulsion the spinal fluid sugar is normal or even increased.

One attack of convulsions, whatever the cause, renders the patient more liable to a second attack and when there have been several, they occur from causes which are less and less marked. In infants who die during convulsions the brain may be the seat of punctate hemorrhages, and sometimes of more extensive ones. The lungs are also deeply congested, and the right heart is generally distended with dark clots.

**Symptoms.**—In some cases prodromal symptoms are present, such as extreme restlessness, irritability, slight twitchings of the muscles of the face, hands, feet, or eyelids. More frequently, however, the attack comes quite suddenly with little warning. Usually the first thing noticed is that the face is pale, the eyes fixed, sometimes rolled up in their orbits; in a moment or two, convulsive twitchings begin in the muscles of the eye or face, or in one of the extremities, which usually extend rapidly until all parts of the body participate. In most cases the convulsions become general, but they may remain unilateral even when not due to a local cause—a point which is often forgotten. The contraction of the facial muscles causes a succession of grimaces, the head is thrown back, the hands are clenched,



the thumbs buried in the palms, and a series of quick spasmodic contractions of the extremities occurs. There may be some frothing at the mouth, and in all true convulsions there is loss of consciousness. Respiration is feeble, shallow, and may be spasmodic. The pulse is weak; it may be slow or rapid; often it is irregular. The forehead is covered with cold perspiration. The face is first pale, then becomes slightly blue, especially about the lips. Unnatural rattling sounds may be produced in the larynx. The bladder and rectum may be evacuated. All varieties of tonic and clonic spasm may be seen, and in all degrees of severity. The contractions of the two sides of the body are usually synchronous. After a variable time, from a few moments to half an hour, the convulsive movements gradually become less frequent, and finally cease altogether, usually leaving the patient in a condition of stupor. They may recur after a short time or there may be but one attack. A period of general relaxation usually follows the convulsive seizures, frequently accompanied by marked evidences of prostration. Transient paralysis is not an uncommon sequel (see page 791).

Death may take place from a single attack; this, however, is rare. There may be no sequel to the convulsions if the cause is a temporary one, or they may produce some serious brain lesion, particularly meningeal hemorrhage; in such circumstances it is difficult to say whether the hemorrhage is the cause or the result of the convulsions. Death from convulsions is generally due to asphyxia. Many cases recover in which the child has for several minutes had the appearance of being moribund.

One attack of convulsions is very apt to be followed in a few days by several others, especially if tetany be the cause. The longer the interval which has passed, the less likely is there to be a repetition, especially if the child has passed his third year.

**Diagnosis.**—There can rarely be any difficulty in recognizing an attack of convulsions. The difficulty consists in determining with which of the many possible exciting causes we have to deal. Tetany is easy to recognize if there is carpopedal spasm, Chvostek's sign, laryngospasm, or Trousseau's sign. If these are absent, the diagnosis can still be made by the serum calcium or the electrical reactions. Chvostek's sign is occasionally positive during and shortly after convulsions of nontetanic origin.

In infancy, epilepsy is the least probable diagnosis. In older children the important points indicating that disease are: a history of previous attacks, especially of nocturnal attacks, a distinct aura preceding the seizure, or a sudden onset with a cry or fall, biting of the tongue, a deep sleep following the seizure, and, finally, perfect recovery in the course of a few minutes or hours. Convulsions which come on with high fever, even though a patient may have repeated attacks, are seldom epileptic. However, in some cases only prolonged observation can enable one to decide positively whether or not the condition is epilepsy.

Convulsions occurring in brain disease, except acute meningitis and encephalitis, are not, as a rule, accompanied by any marked rise in temperature. Focal symptoms are often present, such as localized paralysis or rigidity, changes in the eyegrounds or in the pupils, and strabismus. The convulsive movements are frequently limited to one side of the body. It should, however, be borne in mind



that unilateral convulsions, even when repeated, do not always mean a local lesion, as we have seen proved by autopsy more than once. In hemorrhage or meningitis, convulsions often recur promptly. In tumor they may recur after a longer interval. In encephalitis, particularly the Strümpell-Marie type, and in cerebral thrombosis they may be nearly continuous for many hours.

Convulsions may be thought to indicate the onset of some active disease when they occur in a child over two years old, and when they come on suddenly or with only slight premonition in a child previously well; but the most important point is that they are accompanied by a high temperature—104° to 106° F. Acute meningitis and encephalitis are the only other conditions likely to produce these symptoms. Whether the convulsions mark the onset of lobar pneumonia, scarlet fever, or some other disease, can be determined only by carefully watching the patient's symptoms for twenty-four or thirty-six hours or possibly longer.

In the first weeks of life one may often be in great doubt as to the cause of convulsions. Such attacks may be due to a recent cerebral lesion like hemorrhage, or to defective brain development. Apparently prolonged pressure in a difficult labor may produce temporary, perhaps circulatory, changes in the brain sufficient to cause convulsions during the first few days of life. We have seen them in a number of children whom we have had an opportunity to follow for several years. Their physical and mental development has progressed in a perfectly normal manner.

Examination of the urine should not be omitted in any case of convulsions of doubtful origin; they may be the first warning of advanced renal insufficiency. Asphyxia may be suspected in the case of convulsions occurring in the newly born, late in pneumonia, and in spasmodic or membranous laryngitis. For the convulsions associated with pertussis, gastric tetany is often responsible; in other instances, a pleocytosis in the spinal fluid may be encountered. It is altogether improbable that dentition and worms play any part in the causation of convulsions except perhaps that of the slight irritant which is sufficient to excite convulsions in a child suffering from tetany.

Encephalopathy due to lead should be kept in mind as a rare cause of convulsions in children. There is stippling of the red blood cells, and one can usually elicit a history of ingestion of lead in some form. The blue punctate line in the gums can sometimes be found, though not around each tooth. The cerebrospinal fluid is under increased pressure, the cells are slightly increased in number and there is a positive reaction for globulin; in one of our cases a web formed. There is frequently optic neuritis or pallor of the optic disks, and retinal hemorrhages.

In all cases of convulsions occurring in infants in which the cause is not readily apparent, tetany should be suspected as the underlying condition.

**Prognosis.**—This depends upon the cause of the convulsions, and differs with each underlying cause. It has been said that convulsions in themselves are seldom fatal unless they occur as a terminal condition. Especially fatal are the convulsions of pertussis and those of asphyxia when they occur late in any form of laryngeal or pulmonary disease. The conditions during an attack which should lead one to make a bad prognosis are when the convulsions are prolonged or recur frequently;



also the presence of very great prostration, a feeble pulse with cyanosis, or deep stupor.

In the prognosis one must take into account not only the immediate result of the attacks, but the possible outcome. In a highly nervous or susceptible child a convulsion often means very little. Permanent injury to the brain, simply as a result of an attack, is very rare. The possibility of epilepsy is to be borne in mind in all cases where children over two years old have occasional attacks of convulsions. The farther apart the attacks are and the more definite the exciting cause, the less likely is this to be the case.

**Treatment.**—Summoned to a child in convulsions, the physician should go at once and remain until the attack has subsided. He should take with him ether, a hypodermic syringe with morphine, a soft catheter or rectal tube, and a solution of chloral. In order to treat convulsions intelligently one must have in mind the prominent pathological conditions. These are acute cerebral hyperemia, a more or less severe asphyxia with pulmonary congestion, an overtaxed right heart, and a tendency to congestion of all the internal organs. The nervous centers are in a condition of such unnatural excitability that the slightest irritation may bring on convulsive movements when they have temporarily subsided. The patient should therefore be kept perfectly quiet, and every unnecessary disturbance avoided. Cold should be applied to the head—best by means of an ice-cap or cold cloths—and dry heat and counterirritation to the surface of the body and extremities. The time-honored mustard bath causes so much disturbance of the patient that it can usually be dispensed with and the mustard pack substituted. The feet may be placed in mustard water while the child lies in his crib. The mustard pack and footbath should be continued until the skin is well reddened. The degree to which counterirritation of the skin should be carried will depend upon the condition of the pulse and the cyanosis.

In controlling convulsions the remedies which may be depended upon are the inhalation of ether, chloral per rectum, morphine and magnesium sulphate hypodermically. Ether is undoubtedly the most reliable remedy for an immediate effect, and may be used even in the youngest infant. At the same time that it is being administered, chloral may be given. The initial dose should be: at six months, 4 grains; at one year, 6 grains; and at two years, 8 grains, dissolved in 1 ounce of warm water or milk. It should be injected high into the bowel through a catheter, and prevented from escaping by pressing the buttocks together. It may be repeated in an hour if necessary. The effect of the drug is generally obtained in twenty or thirty minutes. If, in spite of the chloral, the convulsions show a marked tendency to continue as soon as the ether is withdrawn, or if the enema of chloral has been expelled, morphine may be given hypodermically. When the heart's action is weak, this is probably the best of all remedies. To a well-grown child two years old,  $1/16$  grain may be given; one year old,  $1/20$  grain; six months old,  $1/40$  grain. This dose may be repeated in half an hour if no effect is seen. The tolerance for opium in cases of convulsions is very marked, and sometimes double the doses mentioned may be required. For frequently recurring convulsions magnesium sulphate, intramuscularly, is a valuable remedy. Eight or 10 grains may be given to an average infant of three or four months, and from 15 to 20 grains to one of six



or eight months. It does not act as promptly as does morphine. The dose may be repeated in two hours if necessary. The only other agent of much value is oxygen. We have occasionally seen convulsions which continued in spite of all other treatment yield immediately to oxygen. This is most likely to be valuable in cases of convulsions due to asphyxia.

In infancy it is wise to irrigate the colon thoroughly with warm water, to remove any possible source of irritation. If there is high temperature, this should be reduced by the cold bath or pack.

When once under control, a recurrence of the convulsions may be prevented by keeping the patient for two or three days under the influence of chloral with sodium bromide, the amount of chloral being gradually reduced. As soon as the convulsions have ceased, the cause should be sought and treated.

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## CHAPTER CX

### EPILEPSY

Epilepsy cannot be considered a sharply limited disease. Rather, it is to be looked upon as consisting of certain symptom-complexes that are frequently repeated, and which may result from widely different causes. These symptom-complexes take the form of muscular spasms with or without loss of consciousness, and of peculiar mental states, the so-called "equivalents."

A distinction must be made between cases of "idiopathic" or "essential" epilepsy, or those without gross anatomical basis, and those which are secondary to definite lesions of the brain such as old hemorrhage, sclerosis, tumor, etc. Convulsions of the latter character are designated as "symptomatic" or "organic" epilepsy. The nature of the attack, however, may be identical in both varieties, and may differ in no way from convulsions associated with such transient conditions as high fever or tetany. The proportion of idiopathic cases is not so large as was formerly held; many of these have been shown to depend upon lesions once overlooked.

**Etiology.**—Idiopathic epilepsy at its onset is a disease of childhood and youth; 75 to 80 per cent of all cases begin before the twentieth year and 35 to 40 per cent before the tenth year. A comparatively small number begin in the first three years of life. The part played by heredity is a disputed one. The disease is certainly more common in degenerate and feeble-minded families. If one excepts these, a family history of the disease may be obtained in perhaps 10 per cent of cases. Migraine seems to be definitely related to epilepsy. The influence of parental alcoholism is uncertain; it would seem to be a factor in some cases. It was formerly believed that infantile convulsions were not infrequently followed by epilepsy in later years, a belief which has little basis in fact. The majority of convulsions in infancy are of functional origin and leave no sequelae. Convulsions in infancy that are followed by epilepsy are probably epileptic from the beginning. It is likely that birth trauma plays a more important part in the so-called idiopathic epilepsies than has been supposed. According to Ford 2 to 3 per cent of all epileptics can be traced to this cause.

**Pathology.**—Little is known of the pathology of the disease except as seen in the end stages in institutional cases; autopsy reports on children are very few. The findings may be grouped into four classes: (1) scars and brain atrophy resulting from old hemorrhages, trauma, etc., which are the common findings in organic epilepsies; (2) atrophy of the brain, especially the frontal lobes, which is stated by Fay to be present in cases of frequent, long-continued *grand mal* attacks and which he attributes to pressure; (3) gliosis, particularly in the cornu ammonis; (4) Dandy has reported definite findings at operation, consisting of collections of fluid beneath the pia mater, and over areas of the brain that are somewhat atrophied;



these areas may be an inch or more in diameter. At autopsy such changes are not so readily appreciated. Their recognition serves to reduce still further the proportion of cases to be classified as idiopathic. Dandy's observations are of particular interest in view of the success recently obtained with dehydration therapy. It seems probable that a great variety of lesions, many of which are apparently slight, may serve as a background for this disease.

The pathology of the so-called symptomatic epilepsies—those with gross anatomical lesions—will not be taken up here.

The pathogenesis of the attacks is not explained by the demonstration of organic lesions in the brain, even if one grants that such lesions are regularly present. The cause of the motor discharges has been attributed to reflex irritation from worms, phimosis, adenoids, constipation, masturbation, refractive errors, and to various psychic disturbances. The trend in recent years has been to search for abnormal metabolic changes which might contribute to the irritability of the nervous system at particular times. A number of chemical studies have been made in individuals before and after major attacks; it must be admitted, however, that up to the present time no changes have been found which cannot be attributed to the increased muscular activity and the circulatory and respiratory changes accompanying the attack. In spite of these discouraging results, it seems reasonable to believe that some chemical basis will ultimately be found responsible for precipitating the attacks. The success which not infrequently follows treatment with ketogenic diets, starvation and dehydration supports this view.

**Symptoms.**—Two distinct types of epileptic seizures are met with: the major attacks, or *grand mal*, in which there are severe convulsions lasting from two to ten minutes or even longer, with loss of consciousness; and minor attacks, or *petit mal*, in which the convulsive movements are slight and may be absent, and in which the loss of consciousness is often but momentary. Between these two extremes all gradations are seen.

*Grand Mal.*—The onset may be sudden, without premonition, or it may be preceded by certain prodromal symptoms known as the aura. The aura may be motor, such as a local spasm of the hand, face, or leg; or sensory, such as numbness and tingling in any part of the body, or some abnormal sensation rising gradually to the head, at which time loss of consciousness occurs. The variety of sensations described by patients as indicating an attack is endless. There may be a sensation in one finger, in the face, tongue, eye, or in any part of the body; or the warning may be of a general character, like a tremor or a shivering sensation, or a feeling of faintness. There has also been described a visceral aura, in which there is epigastric pain, sometimes nausea, and a sensation of a ball in the throat; or there may be palpitation, or cardiac distress. There may be general giddiness or vertigo, or a sensation of fullness in the head; or feelings of strangeness, or a dreamy, dazed condition; and, finally, the aura may have reference to any of the special senses, most frequently to sight. Sparks may appear before the eyes, or flashes of light or color, or strange objects may be seen; there may be a momentary loss of hearing, or strange sounds may be heard. In most cases the aura is peculiar to the individual and is identical in successive attacks.

At the beginning of the seizure the face becomes pale, the pupils widely dilated,



the eyes rolled up in their orbits and fixed. Speedily there is loss of consciousness. Simultaneously with these symptoms, or immediately following them, there occurs a violent tonic muscular spasm to which are due the characteristic symptoms of the early part of the seizure: the fall, cry, biting of the tongue, cyanosis, and evacuation of the bladder or rectum. The fall is forcible, violent; in fact the patient is precipitated, usually forward, and frequently suffers injury, not often sinking down as in a faint. The head or the eyes may be strongly rotated to one side. The position of the hands is frequently that assumed in tetany. The cry is a hoarse, inarticulate sound, not very loud, and is due to forcible expiration, owing to spasm of the muscles of respiration with the glottis partially closed. The cyanosis is the result of tonic spasm of the muscles of respiration; it may be quite intense, so that the face is livid, bloated, and the features distorted. The spasm of the muscles of mastication causes the biting of the tongue. Evacuation of the bladder and rectum may result from contraction of their walls, or from spasm of the abdominal muscles. The violence of the muscular spasm in this stage may be very great; it has caused fracture of bones, rupture of muscles, and even dislocation of joints.

The stage of tonic spasm may be only momentary, although usually ten seconds to half a minute intervene before the clonic convulsions begin. The muscular contractions are violent and rhythmic and there is often frothing at the mouth. Gradually the muscles of respiration relax, air enters the lungs, and the cyanosis passes off. After the clonic spasm has continued for a variable time—from two or three minutes to half an hour—the muscular contractions become less and less frequent, and finally cease altogether. In a few minutes the patient may regain consciousness, look vacantly around, and in a dazed way perhaps ask what has happened, being completely oblivious to all that has occurred. More frequently he passes at once into a deep sleep, which continues for an hour or more, but from which he can be aroused. During the early part of the sleep the eyes may roll from side to side. He usually awakens with a severe headache, which may continue for several hours. After this he often feels better than for several days preceding the attack. During the seizure the temperature may be elevated one or two degrees.

Violent focal seizures are not infrequently followed by paresis, or even paralysis, of the affected limbs and less commonly aphasia or hemianopia, depending on the site of the cortical discharge. Almost invariably these symptoms disappear within a few hours or days, but in rare cases persistent hemiplegia has been observed. We have seen cases in which a series of general convulsions were followed by widespread paresis of the muscles, loss of speech, increased reflexes, Babinski phenomenon, apparent deafness and blindness. These children did not make a complete recovery until several weeks after the convulsions had ceased. To differentiate this condition from encephalitis is often very difficult. Vomiting or intense hunger may follow convulsions. In rare cases the urine may contain a trace of sugar.

*Petit Mal.*—The minor attacks of epilepsy may present a great variety of symptoms, and at times it is almost impossible to decide that these are epileptic except from their periodic occurrence. They pass under the names of “staring spells,” “absences,” “attacks of dizziness,” “fainting turns,” etc. The most striking thing



which stamps them as epileptic is the loss of consciousness, which may be of short duration, sometimes so momentary as to pass unnoticed. There is usually no fall, but there may be a slight dropping of the head, a fixed stare for a moment or two, and that is all. The muscles are often firmly contracted so that the child stands straight and stiff. Occasionally there are one or two contractions of the arms or a violent bending forward or nodding movement of the head. These attacks may or may not be preceded by an aura. After such a mild attack the patient usually recovers immediately and completely, but at times he may be somewhat confused for a few moments or he may become sleepy. One of the most striking things about attacks of *petit mal* is their frequency; as many as thirty or forty attacks may occur in one day. *Petit mal* is a serious form of epilepsy and after a time is usually associated with *grand mal*.

*Equivalents* are attacks in which only an abnormal mental state is manifested. They may come on after an attack of *grand mal* or *petit mal* or they may occur with no previous attack, apparently taking the place of one of them. Sometimes they are the first evidence of epilepsy. There may be for a time a complete alteration in the disposition of the child. He may have uncontrollable fits of anger, be disobedient or destructive, run away, and, in rare instances, even acts of violence have been committed; or he may be apathetic, lethargic, as if completely dazed. Upon recovery from such a state, which is usually sudden, there is generally no recollection of what has occurred.

In symptomatic epilepsy the seizures may be in all respects identical with the above. Quite frequently, however, the convulsions are of the so-called jacksonian type with spasms of localized groups of muscles in the face, arm, or leg and with retention of consciousness. The convulsion may start as a localized twitching and spread in orderly sequence over the body, eventually becoming generalized with loss of consciousness. The most frequent lesion producing this form of epilepsy is a cerebral tumor, but almost any abnormal process involving the cortex may be the cause. Jacksonian epilepsy is discussed under the diseases in which it may be found.

*Mental Condition of Epileptics.*—That epilepsy is not infrequently associated with mental deficiency cannot be denied, nor indeed is it surprising in view of the large number of cases in which organic disease of the brain can be demonstrated. Whether epileptic convulsions will in themselves lead to mental deterioration is a question which cannot be answered with certainty. There is reason for believing that frequently repeated *grand mal* attacks will in the course of time do this. However, approximately 50 per cent of the noninstitutional cases analyzed by Lennox showed no mental changes even after the disease had gone on for fifteen to twenty years. When the attacks are infrequent or are confined to the *petit mal* type, the chances of mental deterioration are more remote.

It has been our experience that the diagnosis of mental retardation is often erroneously made. The epileptic child is, as a rule, surrounded by unusual social influences; too often he is excluded from schools and his education may be entirely neglected. Such factors must be given due weight in mental standardization tests.

**Course of the Disease.**—In most cases seizures first occur at long intervals, perhaps a year apart, but later they become more and more frequent. Either the



mild or the severe attacks may be first seen, and may remain throughout as the only type present, or both may be associated in the same case. There are most frequently seen occasional major attacks with a large number of minor ones. The interval between the epileptic seizures in most cases is from two to four weeks, although they may be of daily occurrence. Sometimes three or four seizures will follow one another closely, followed by a long interval of freedom. The seizures may come on either during sleep or in the waking hours; in some cases they occur only in sleep. Such cases present peculiar difficulties in diagnosis, and are often long unrecognized as epileptic. The general health of patients may be quite normal.

Death rarely, if ever, results from epilepsy, except from some accident at the time of the seizures, or from the condition known as *status epilepticus*; in this the attacks come on with great frequency and severity, the patient at times passing rapidly from one convulsion into another, the temperature rising to 105° or 106° F., and death occurring in coma.

**Diagnosis.**—The major attacks are usually easily recognized when they occur by day. Nocturnal attacks offer more difficulty, but the presence of a cry, biting of the tongue, blood upon the pillow, subconjunctival extravasation, evacuation of the bladder or rectum, and the severe headache help to distinguish the true epileptic seizure from hysterical attacks or from night-terrors. Minor attacks present the greatest difficulties, and a positive diagnosis is often impossible until the patient has been watched for a long time. The most important points to be noted are sudden pallor, dilatation of the pupils, a blank, far-away expression to the eyes, temporary loss of consciousness, or simply mental confusion, with sudden recovery as a rule. Mild attacks are to be distinguished from absent-mindedness, hysteria, masturbation, and occasionally from unsuspected deafness. Psychic equivalents can only be suspected unless there is a history of attacks of *grand* or *petit mal*.

The distinction between the idiopathic and organic forms of the disease may be quite impossible. The age of onset may be of some help; attacks continuing from the first year of life suggest an organic lesion—either a birth injury or malformation; with an onset later in life this is more doubtful. Convulsions of the jacksonian type indicate an organic lesion, but it must be remembered that organic disease does not necessarily produce local convulsions. Evidence of muscular atrophy, weakness, changes in the reflexes, changes in the eyegrounds, or other focal neurological signs, will often give the clue to the presence of organic disease. At other times only the course of the disease will reveal its nature.

**Treatment.**—General hygienic measures should never be neglected in epilepsy. The common mistake is to rely solely on specific means of treatment. Although “reflex causes” may play only a minor part in precipitating seizures, it is wise to remove them whenever possible. Children should lead a simple, regular life, as much as possible out-of-doors. Exercise should be abundant, but undue fatigue and excitement are to be avoided. A well-disciplined child usually does better than one badly controlled. The diet should be simple but adequate; constipation and over-eating should be avoided.

Recently it has been found possible to influence epilepsy, sometimes in a very striking way, by dietary measures. Periods of *fasting* were used at first; fre-



quently they resulted in disappearance or great diminution of the attacks for long periods of time. Fasting produces a ketone body acidosis; it also causes a loss of water and minerals from the body. It is still uncertain which of these effects is responsible for the benefit. Successful results have been reported with restriction of minerals alone. An acidosis produced by mineral acid is without benefit. It is now well established that either a regimen of dehydration or the use of a high fat diet (which leads to ketosis) are valuable methods of treatment. These have largely supplanted the original fasting therapy.

*Ketogenic diets* have obvious advantages over fasting; they may be continued almost indefinitely if desired. The difficulties of such a regimen are numerous. All food must be carefully weighed and calculated; the articles of diet which can be allowed are few and the diet is likely to become monotonous. It has been shown that the therapeutic effect of such a diet is more constantly obtained if it is preceded by a short period of fasting. It is our practice to start with five or six days of complete fasting, during which only water is given. Rarely a crisis of weakness and slow pulse develops which is in all probability due to hypoglycemia, for it is controlled by giving orange juice. Following the fast, the full ketogenic diet is given. The chief foods used are butter, 40 per cent cream, mayonnaise, eggs, bacon, meat and coarse vegetables. The use of "cellubran" products, which have no caloric value, makes the diet more palatable. The diet should be adequate in calories and should contain at least 1.25 gram of protein per kilogram of body weight. It is usually possible to supply from 80 to 90 per cent of the calories in the form of fat. The diet should be tried for several months to test its efficacy; if effective it should be continued for at least a year; one may then gradually return toward a normal diet. If attacks recur the diet can be resumed. In our experience this regimen—a ketogenic diet preceded by a period of fasting—has given encouraging results, both in cases with major and those with minor seizures. The attacks may stop abruptly for a longer or shorter period of time. Some patients remain free for years, in others little or no benefit is obtained.

The use of *dehydrating diets* has recently been popularized by Fay and by McQuarrie. The diet is made as dry as possible by omitting liquid foods, fruits, green vegetables and by giving baked in preference to boiled dishes. A reduction in the amount of salt aids in controlling thirst. The total fluid intake must be cut down gradually; in the course of two weeks it may be reduced to 200 c.c. a day or even less. Enemata are contraindicated. On such a dry regimen the urine volume approximates very closely the volume of the liquid drunk; water present in the food balances the loss through the skin, lungs and bowels. Before instituting this form of treatment one should be certain that renal function is normal. In no case is it wise to allow the urine output to fall below 200 c.c. a day. Thirst is seldom complained of after the second week; it may be relieved by sucking moist blotting paper, by sucking cracked ice, or by chewing gum. Fever may occur if dehydration is instituted too rapidly or carried too far; this is to be avoided. With acute infections it may be necessary to increase the fluid intake until the urine volume reaches 300 to 500 c.c. a day, but fluid should not be forced. A marked loss of weight invariably accompanies dehydration and should occasion no concern. The diet should be continued for at least three months, if it is to be given a thor-



ough test. If satisfactory results are obtained, it may be continued indefinitely. If the attacks disappear one may after a year gradually return to a normal regimen.

There can be no question that one of the effects of ketogenic diets is to dehydrate the body. The success obtained with such diets has been attributed to this change alone. Such a view cannot be accepted without reserve at the present time, for there is clinical evidence to the contrary. It has been the experience of some observers that dehydration alone is ineffective in cases of *petit mal* attacks, while a ketogenic diet is quite as effective in controlling these as with *grand mal* attacks. There is no objection to combining a moderately high fat diet with water restriction. A diet containing little sodium exerts, likewise, a dehydrating effect.

It is not always practicable to employ these special diets; they should, however, be tried whenever possible, and given at least a three months' trial. Drugs must be withheld during this period if a fair opinion of the effectiveness of the diet is to be obtained. If the diet is only partially successful one may continue it and supplement it by the use of sedatives.

Nearly every form of sedative has been used in epilepsy. Bromides have been the favorite drugs in the past, but of late years they have been to a large extent supplanted by various barbituric acid derivatives. Phenobarbital (luminal) is most frequently employed; a dose of  $\frac{1}{4}$  to  $\frac{1}{2}$  grain three times a day may be given to a child of five years; it may be necessary to give more than this. The drug must be given with absolute regularity, if its effect is to be maintained. Phenobarbital will often cause an abrupt cessation of convulsions; the effect is, however, seldom permanent. After a period varying from a few weeks to a year or more, the convulsions gradually reappear. A similar experience may be met with in using bromides or other drugs; the body seems to acquire a tolerance to them after a time. There may be a distinct advantage in using first one sedative for a period of months and then shifting to another. It is our practice to commence with luminal and subsequently to shift to bromides. Children require proportionately larger doses of bromide than adults; a child of five years may need 25 to 40 grains of potassium bromide a day before the physiological effect is obtained. It is advisable to reduce the intake of sodium chloride, for chloride causes the excretion of bromide and necessitates giving larger amounts. Bromides must be given with absolute regularity; as is the case with other sedatives, the omission of a few doses may bring a return of convulsions. One must of course be on the watch for the various symptoms of drug intoxication which these substances may produce.

The *surgical treatment* of epilepsy has attracted considerable attention. An operation may be considered if a cortical lesion can be localized, as may be the case when the condition has followed trauma or when the convulsions are jacksonian. The results of operation have been disappointing. The removal of cortical scars may arrest attacks for a time, but they usually recur.

*Management of the Attack.*—Abortive measures are sometimes successful in cases with a distinct aura, the most reliable being the inhalation of amyl nitrite. While the seizure lasts, the patient should be prevented from injuring himself. The clothing should be loosened, a spool or cork should be placed between his teeth to protect the tongue, but no effort made to restrain his movements unless



he is likely to do violence to himself. An epileptic child should never be without some companion.

Status epilepticus requires prompt and active treatment. A high cleansing enema should be used. Inhalations of ether often bring immediate relief; if not permanent this should be followed by a generous dose of morphine or codeine. Avertin promises to be of value. Lumbar puncture with slow drainage of large amounts of spinal fluid is often a helpful procedure. The intravenous injection of phenobarbital (5 to 10 grains) has been recommended.

The education of the epileptic child is often a matter of great difficulty. A prejudice against such children is often responsible for their exclusion from ordinary schools; it is very desirable that special schools and colonies be established for patients whose seizures cannot be controlled.

**Prognosis.**—The outlook for the epileptic child to-day is somewhat more hopeful than in the past. Spontaneous recovery may occur, particularly in the case with infrequent seizures of the grand mal type. The outlook is less favorable when there are petit mal as well as grand mal attacks and when the attacks are frequent. By means of diet and sedatives perhaps half of these patients can be helped; in a few the disease can be completely arrested. The remainder do not respond to medical treatment. If the convulsions can be controlled it seems unlikely that mental deterioration will occur, provided the mentality is normal at the outset; and even in cases where the attacks continue with moderate severity, fully half of the patients remain mentally sound.

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## SECTION XVII

### ORGANIC DISEASES OF THE NERVOUS SYSTEM\*

#### CHAPTER CXI

#### PECULIARITIES OF THE NERVOUS SYSTEM IN INFANCY

**Myelination.**—At full term the development of the infant's nervous system is still far from complete, and large areas of the cerebral cortex are still devoid of myelin. Flechsig showed many years ago that cortical areas surrounding the fissure of Rolando, the calcarine fissure, the superior temporal gyrus and part of the hippocampal gyrus are the first to become myelinated and that this process is complete or nearly complete in these areas at birth. These he called *projection* centers, for he believed that they all receive sensory impulses from the thalamus. The other cortical areas in which myelination is delayed he termed *association* centers. Myelination of some tracts of the spinal cord and brain stem is also incomplete at birth. The spinal roots are said to acquire their myelin sheath as early as the fifth month of intra-uterine life. The anterolateral columns are myelinated next, later the posterior columns, spinocerebellar tracts, and finally the rubrospinal and pyramidal tracts. The last are not completely developed before somewhere between the ninth and tenth month of extra-uterine life. In general it may be said that the afferent pathways and their cortical projection areas are more or less complete at birth, as are the segmental structures of the spinal cord and brain stem. The corticospinal pathways, however, are still only partially developed.

**Development of Cortical Functions.**—It has been generally assumed that myelination parallels the development of functional activity of the nervous system. This rule is subject to very definite exceptions in the lower animals, but it is none the less true that there is a rough parallelism. The activities of the newly born infant are all reflexes mediated by the spinal cord and brain stem. A number of instances have been observed of infants showing all the normal reactions, including crying, nursing, and vigorous movements, who were found at autopsy to have a congenital absence of the cerebral hemispheres. This indicates very strongly that the hemispheres play little or no part in the normal activities of newborn babies. This same conclusion is supported by the fact that even severe hemiplegias or diplegias due to birth injury or intra-uterine processes are usually not apparent for several months and may not be recognized for a year. Mental defects may not be evident until much later. It is probable that the motor centers of the newly born are not entirely insensitive to irritation, for local twitchings and convulsions at birth may result from supratentorial hemorrhages.

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\* For general references on neurology, see page 804.



**General Pathology of the Nervous System.**—The response of the nervous system to disease shows a number of peculiarities in early life, which can doubtless be attributed to incomplete development. Cerebral lesions in infancy often result in failure of development of other parts of the nervous system not directly injured. For example, a lesion in one hemisphere is always associated with defective development of the opposite cerebellar hemisphere. This fact may be offered in explanation of the well-known observation that injuries to the nervous system of infants ultimately lead to much greater disability than comparable injuries in adults.

The peculiar susceptibility of the infant to convulsions during the first two or three years of life is discussed more fully in the special article devoted to that subject. It is difficult to explain this phenomenon on the basis of hyperirritability of the nervous tissue. The peripheral nerves are known to be less irritable to galvanic stimuli in the first few years of life.

**Clinical Examination of the Nervous System.**—A satisfactory neurological examination in children offers many difficulties; in young infants it is necessarily incomplete. The procedures used differ in some particulars from those employed with adults, partly because of the inability of the child to coöperate in certain tests, partly because the pathological conditions encountered in young children are in some respects peculiar.

*The Head.*—Inspection and measurements of the head form an important part of a neurological examination in a young child. Before the sutures and fontanelles have closed, the skull is capable of marked increase in size as a result of intracranial pressure. Much information can be obtained by observing the fontanel, whether it is bulging or depressed.

The percussion note of the skull is greatly influenced by the degree of patency of the fontanelles and sutures. In the young infant, when these are widely patent, scarcely any resonance is obtained; the note is dull and low-pitched. Familiarity with the variations in percussion at different ages is essential if one is to use this procedure in diagnosis.

*The Cranial Nerves.*—The *first nerve* cannot be tested satisfactorily in very young children. One should not make the mistake of using substances that irritate the mucous membranes in order to elicit a response. In testing the *second nerve* in children who cannot read, one must rely on the recognition of familiar objects; with infants one may observe whether the eye follows moving objects, and whether a threatening gesture will cause the eyes to close. The fields of vision can rarely be outlined satisfactorily; it is better to hold the test object in the hand, rather than to try to use a perimeter. Examination of the fundi is often irksome to young patients and is therefore best deferred till the end of the neurological examination. *Third, fourth, and sixth nerves:* it is usually possible to make a satisfactory examination of the pupils and external ocular movements; even a young infant will attempt to follow a light. Coördinate movements of the eyes are usually established at about the third month, but some degree of incoördination may persist for many months. *The fifth nerve:* the motor function may be determined by palpating the masseters during chewing. Sensibility is difficult to test in children; the corneal reflex is, however, a good index of the function of this nerve, since it is diminished or lost when the sensory root is injured. *The seventh nerve:* much information



can be gained here by observing the wrinkles of the face during laughing and crying; it must be remembered, however, that normal facial movements during emotions are not incompatible with paralysis of voluntary movement, hence one should always test for voluntary movements when this is possible. *The eighth nerve* offers no difficulties with older children; the hearing of infants can be tested by their response to sudden and loud noises; the ear drums should always be examined. The vestibular branch may be tested as in adults by the development of nystagmus following irrigation of the ear with cold water. *The ninth and tenth nerves* are usually tested together. The gag reflex is present at birth. Palate paralysis or weakness will be indicated by regurgitation of food or water through the nose. The quality of the voice gives added information in regard to conditions in the nasopharynx and larynx which involve their innervation. Examination of the *eleventh and twelfth nerves* requires some degree of coöperation to be satisfactory.

*Motor System.*—Great difficulty is encountered here in examining subjects too young to coöperate in performing voluntary tests. One is forced to rely to a great extent on observation of the child's position and spontaneous activities. Palpation of the muscular system, at rest and during passive movements, may yield some information, as may the observation of abnormal movements. Strength and coördination are gradually acquired during infancy and childhood, and much experience is needed to recognize slight departures from the normal. Data in regard to normal development are given in another place. Sphincter control in young children depends to a considerable extent on training. Occasional incontinence of urine up to the age of three or four years should not be considered abnormal; continuous dribbling, however, always indicates organic disease.

The determination of *sensibility* is limited in young subjects; in infants only pain sense can be demonstrated. This is best done by pinching or pricking with a pin. It is important to produce no more pain than necessary; a child who is hurt or frightened will continue to cry whenever he is touched, and the result will be misleading.

*Reflexes.*—The deep reflexes are fully developed even in infants. In eliciting them it is desirable to have a smaller, lighter hammer than those usually employed with adults. Many of the superficial reflexes are not present at birth. The abdominal reflexes appear first between the second and sixth months. Plantar stimulation gives little information during the first year. It is between the fourteenth and eighteenth month that the normal response changes from extension to flexion.

*Diagnostic Punctures.*—The technic of lumbar puncture, cisterna puncture and ventricular puncture are considered elsewhere (pages 42, 43). A number of other special procedures are used in the diagnosis of lesions of the nervous system.

In cases in which subdural hematoma is suspected, subdural puncture is indicated. This may be accomplished by introducing the needle through the outer corner of the anterior fontanel and directing it laterally so as to keep the point close to the under surface of the dura. Thrombosis of the superior longitudinal sinus may be diagnosed sometimes by puncture through the anterior fontanel in the midline. Sinus puncture is sometimes employed to obtain blood or to give transfusions.



Lumbar and cisterna puncture must be carried out with great caution in all cases in which there is evidence of increased intracranial pressure, and especially in case of posterior fossa tumors. Under these circumstances there is some danger of death from respiratory failure. There is also very frequently an increase in symptoms after lumbar puncture in cases of spinal cord tumor; and when the lesion is above the phrenic nucleus, lumbar puncture should never be done unless it is possible to operate at once. The bacteriological, cytological and chemical procedures employed in examining the cerebrospinal fluid do not differ from those used with adults. They may be found in all laboratory manuals. The table on the following page gives the characteristic changes in the spinal fluid in conditions encountered in early life.

*Tests of the Patency of the Spinal Canal.*—Several very useful tests have been devised recently which enable us to determine the presence of a block in the spinal canal and also to localize the obstruction. One of the simplest consists in injecting 20 or 30 c.c. of air into the lumbar subarachnoid space and then, after the patient has been kept in an upright position for some minutes, to take a roentgenogram of the head. The presence of the air is easily demonstrable by this method; it is sometimes accompanied by occipital and frontal headache. If the air does not reach the skull, there is almost immediately sharp root pain at the site of obstruction and the sensory level is usually accentuated. The air can rarely be seen in the spinal canal. The Queckenstedt test is very valuable. Lumbar puncture is performed with the patient lying horizontally and a manometer is attached to the needle. The pressure is noted and the jugular veins are then compressed, causing venous congestion of the brain and consequently increased intracranial pressure. If the spinal canal is patent the pressure will rise in the manometer; if not, the manometer will show no change. This test has been employed by Ayer to demonstrate lateral sinus thrombosis. In such cases if the affected jugular vein is compressed, no rise in pressure in the manometer is observed, but when the opposite vein is compressed there will be a rise comparable to that obtained when both veins are compressed in normal individuals. A third test for spinal block consists in injecting lipiodol into the cisterna magna. This substance is much heavier than the spinal fluid and sinks slowly down the canal until it encounters some obstruction. In case there is no block the lipiodol collects opposite the body of the second sacral vertebra, but in cases of spinal tumor the lipiodol accumulates in the form of a cap about the upper pole of the tumor. The lipiodol shows clearly in roentgenograms, and hence this method gives very exact localization.

*Ventriculography and Encephalography.*—Dandy's method of roentenographic visualization of the cerebral ventricles by filling them with air is now widely used, and is of the greatest value in neurological diagnosis. The air may be injected directly into the ventricular system through a trephine opening or through the fontanel, as was originally recommended, but preferably it is introduced by lumbar puncture. A few cubic centimeters of fluid are withdrawn and replaced by as much air, repeating the process until no more fluid can be removed. If there is any suspicion of a brain tumor, ventricle puncture is to be preferred, for lumbar puncture is dangerous. The significance of various changes in the ventricular system has been fully discussed by Dandy and others. In brief these alterations are



TABLE XLVI

## THE CHARACTERISTICS OF THE CEREBROSPINAL FLUID IN PATHOLOGICAL CONDITIONS

Disease	Pressure	Appearance	Cells	Protein		Sugar	Remarks
				Qualitative (globulin)	Quantitative (mg. per 100 c.c.)		
Normal	70-200 mm. of fluid	Clear Colorless No coagulum	1-15 All mononuclears	0	15-40	50-75 mg. per 100 c.c.	
Meningismus	Increased	Clear Colorless No coagulum	5-40 All mononuclears	±	40-80	Normal	
Lead encephalopathy	Increased	Clear Colorless Coagulum ±	10-60 Mononuclears	++ to ++++	Increased	Normal	
Brain abscess	Usually increased	Clear Colorless No coagulum	Often up to 100 P.M.N. usually predominate	±	30-125	Normal or increased	Organisms are usually ab- sent.
Acute poliomyelitis	Usually increased	Clear Colorless Coagulum ±	25-500 Chiefly P.M.N. Later the count falls and monos. predominate	+	30-60 Later 100-200	Normal	
Mumps meningitis	Increased	Clear or opalescent Colorless No coagulum	15 to 200 Monos. usually predominate	±	60 to 125	Slightly increased	
Epidemic encephalitis	Usually 200 mm. or more	Clear Colorless Coagulum rarely	10 to 150 Mononuclears	±	20-60	65 to 100 mg. per 100 c.c.	
Measles or vaccinia encephalitis	200-400 mm.	Clear Colorless Coagulum rarely	15-200 Usually monos., rarely P.M.N.	±	Up to 90	Sometimes reduced to 25 mg. per 100 c.c.	



Neurosphilis	Normal or slightly increased	Clear Colorless No coagulum	10-200 Mononuclears	+ to ++	50-150	Normal	Wassermann positive. Colloidal gold or mastic tests may give paretic or irregular curves.
Tuberculous meningitis	500-1000 mm.	Clear or opalescent Colorless Coagulum +	25-500 Usually monos. predominate	++ to +++	60-1000	Falls to 15 or 20 mg. per 100 c.c.	Tubercle bacilli present.
Chronic basilar meningitis	Increased	Clear or opalescent Colorless Coagulum +	100-500 Mononuclears predominate	++	Increased	Below normal limits	Occasional organism found.
Medullo-blastoma	Slightly increased	Clear Colorless or yellow Coagulum ±	Up to 200 Monos. predominate Mitoses may be seen R.B.C. ±	+ to +++	Increased	May be reduced	
Acute purulent meningitis	500-1000 mm.	Turbid Usually colorless Coagulum +	Up to 6000 or more; P.M.N. predominate	++ to +++	50-500	Falls to 10 mg. per 100 c.c. or less	Organisms demonstrable. Indol is present if B. influenzae is cause.
Compression syndrome (Froin's syndrome) (Spinal block)	Normal or low	Clear Yellow or colorless Massive coagulum	Normal	++++	Up to 2000	Normal	
"Bloody tap" (Normal fluid mixed with blood)	Normal	Pink or red Clear and colorless supernatant fluid on standing Coagulum +	R.B.C. appear normal No excess of W.B.C.	Normal or +	Slightly increased	Normal	Less blood in successive tubes. Benzidine on supernatant fluid is negative.
Subarachnoid hemorrhage after 24 hrs.	Increased	Yellow or orange Supernatant fluid xanthochromic No coagulum	R.B.C. crenated Excess of W.B.C. present	+	Slightly increased	Normal	R.B.C. persist 8 to 12 days. Benzidine neg. after 72 hrs. Van den Bergh usually positive after 24 hours.



due to two factors, compression and displacement of the ventricle by direct pressure, and dilatation of the ventricle as a result of obstruction to the outflow of cerebrospinal fluid or by loss of tissue. For example, if there is a tumor in the right hemisphere, the right lateral ventricle will be displaced to the left and compressed, and if the growth has extended into the third ventricle or has occluded it

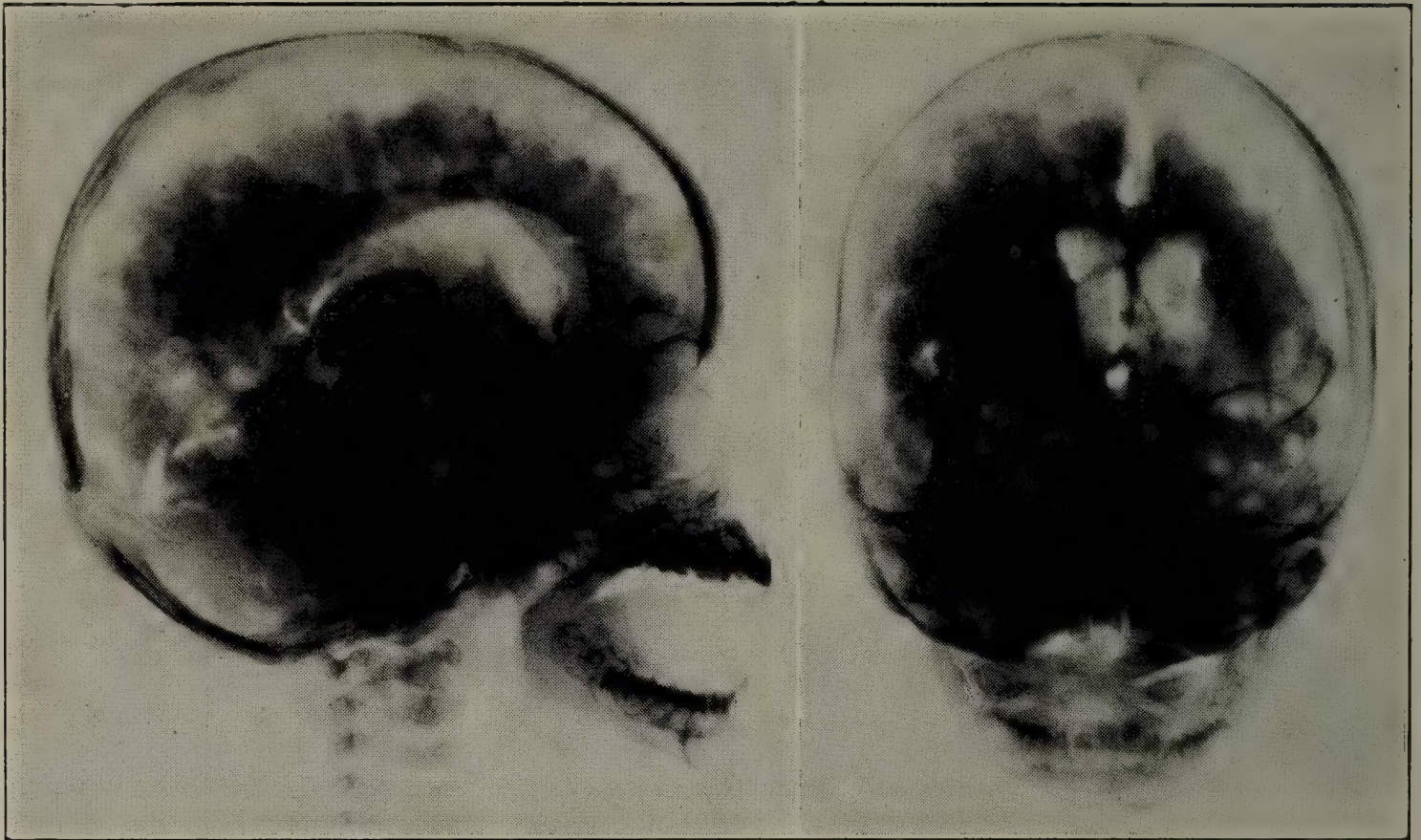


FIG. 117.—ENCEPHALOGRAM, SHOWING DISTORTION OF THE VENTRICLES AND DILATATION OF THE CORTICAL SUBARACHNOID SPACE, WITH SHRINKAGE AND DISTORTION OF THE CEREBRUM.

Josephine C. (B.H. 317700), age seven and one-half months. Patient brought to hospital at three and one half months of age with convulsions and coma, elevated blood pressure, bulging fontanel, separation of the sagittal suture, subhyaloid retinal hemorrhages, bloody and xanthochromic spinal fluid. The diagnosis of hemorrhagic pachymeningitis was confirmed by subdural puncture through the fontanel. Although she never had another hemorrhagic episode, her recovery was prolonged: there was bilateral optic atrophy and apparently complete blindness; stationary head circumference over a period of four months; retardation of mental growth. Encephalography confirms the poor prognosis for subsequent mental development.

by pressure, the left lateral ventricle will be dilated. In the same way growths which occlude the aqueduct or the fourth ventricle will give rise to bilateral hydrocephalus. Destruction of brain tissue results in outpouching of the ventricle, and often in the formation of large collections of fluid over the cortex (external hydrocephalus). External and internal hydrocephalus, porencephalus, and many other cerebral defects may be recognized by this method.

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## CHAPTER CXII

### CONGENITAL ABNORMALITIES OF THE NERVOUS SYSTEM

**Introduction.**—Under this heading are discussed a great variety of conditions which have in common only the fact that they all become apparent soon after birth. It includes gross malformations, failures or arrests of development, and the results of intra-uterine injuries and diseases. The great difficulty in separating cerebral palsies, due to hemorrhage at birth, from prenatal conditions has made it necessary to include them in the same group. The arrests of development are very imperfectly understood, although some progress has been made by experimental methods. It has been shown by Stockard that if fish embryos are placed in the ice-box for brief periods during which certain organs are undergoing their period of maximum growth, the development of those organs will be arrested and cannot subsequently be resumed, so that a permanent malformation results. It is possible that transient disturbances in embryonic oxygenation, such as might result from defective implantation of the ovum or from infarction of the placenta, might cause similar arrests of development *in utero*. It is now well known that therapeutic irradiation over the pelvis with radium or roentgen rays during the course of pregnancy results in a large percentage of defective children. In a series of 75 children, 38 were defective. In 18 cases there was microcephaly; idiocy, spasticity, blindness, microphthalmia, spina bifida, clubfoot, oxycephaly and hydrocephalus were also found. Defective heredity seems to play some part in the genesis of congenital defects, but its rôle is a small one in contrast to its leading part in the etiology of progressive degenerations of the nervous system. Intra-uterine diseases are apparently rare and, indeed, little is known about the subject except for the various types due to syphilis.

### GROSS MALFORMATIONS OF THE BRAIN

The malformations of the brain are of very great variety, and many of them are solely of anatomical interest, as the conditions are incompatible with life. Only the most frequent and the best known types will be described and those which are of interest from a clinical point of view.

**Anencephaly.**—This term is applied to those cases in which the cerebral hemispheres are more or less completely absent. Usually the brain stem and basal ganglia are present, and the cerebellum is more or less completely developed. The space usually occupied by the hemispheres is filled with fluid.

**Meningocele, Encephalocele and Hydrencephalocele.**—These three conditions have in common a protrusion of some part of the cranial contents through an opening in the skull. In meningocele there is a protrusion of the membranes alone. These form a sac which communicates with the subarachnoid space and which is usually, but not invariably, distended by fluid. In encephalocele there is a



protrusion of a portion of the brain substance; this is connected with the rest of the brain by a constricted neck or pedicle. Fluid when present is external to the brain. In hydrencephalocoele there is a protrusion of a portion of the brain substance which contains within it part of the cerebral ventricles. Meningocele and encephalocoele are of prenatal origin and are due to primary developmental defects. They may or may not be associated with hydrocephalus. Hydrencephalocoele may be either congenital or acquired; the form which appears after birth is a result of hydrocephalus. The increasing intracranial pressure finds a weak spot in a fontanel



FIG. 118.—MENINGOCELE IN INFANT ONE MONTH OLD.

which yields. Herniation of the cerebral contents results. In time this swelling may become enormous.

In all of these conditions there is a tumor, usually pedunculated, of a round or pyriform shape, with a smooth or lobulated surface. The ordinary size is that of a mandarin orange; it may be as small as a walnut or as large as the patient's head. It is generally covered by the scalp, which is often denuded of hair; or like a spina bifida it may be covered only by granulation tissue. It may show a central cicatrix. Other deformities, such as spina bifida, clubfoot, and harelip are frequently present.

These tumors are rare. They are usually serious, especially so when associated with hydrocephalus. With rare exceptions they arise in or very close to the median line and usually in the frontal or occipital regions, more frequently the latter. The



occipital protrusions may communicate with the posterior fontanel, with the foramen magnum or with the cleft of a spina bifida. The occipital bone may be divided in the median line or rarely it may be absent.

In the nasofrontal form the tumor is usually at the root of the nose, a little to one side of the median line. The aperture is most frequently between the cribriform plate of the ethmoid and the frontal bones. It may be between the lateral halves of the frontal bone, causing a median tumor. The point of protrusion may also be the lateral region of the skull or along the line of sutures. The tumor may

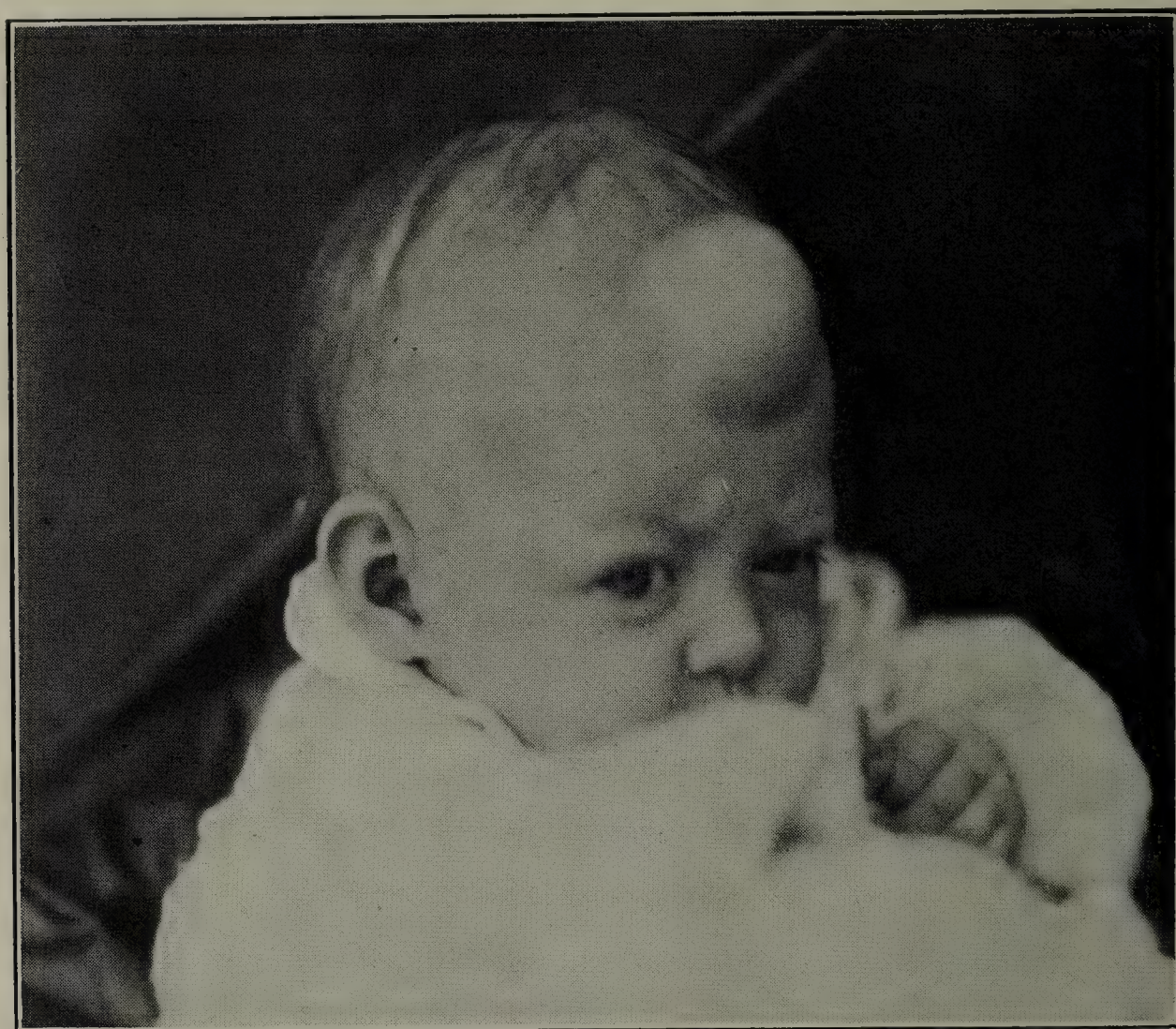


FIG. 119.—FRONTAL ENCEPHALOCLE IN INFANT THREE MONTHS OLD.

project into the mouth or the pharynx. These anterior tumors are usually small, although large ones containing the anterior lobes of the brain have been seen.

*Symptoms.*—A typical tumor is round and elastic, giving evidence of fluid. When the communication with the cranial cavity is sufficiently large it usually pulsates synchronously with the heart, and during crying or forced inspiration it increases in size. Partial and in some cases complete reduction of the swelling is at times possible, but this may be followed by marked symptoms of intracranial pressure. After partial or complete reduction an opening in the skull can often be palpated. Microcephaly or hydrocephalus may be present or there may be an unequal development of the two sides of the head. The diagnosis seldom offers difficulties. Cephalhematoma may be distinguished from meningocele by the fact that it is situated on one side, usually over the parietal bone; it never extends across the midline or a suture line, and it cannot be reduced. Moreover, it begins to disappear in a few days. Many of the patients with large malformations die in the



first few weeks of life. This is particularly true of those patients with tumors in the occipital region. Death apparently results from disturbance of the medullary centers. Others die of meningitis following rupture of the sac. Most of these patients exhibit signs of mental impairment or other manifestations of organic brain disease.

*Treatment.*—The treatment of these tumors depends upon many factors, such as the age of the child, the size and kind of the tumor, the presence of hydrocephalus, other evidences of malformation of the brain, and the mentality of the



FIG. 120.—MICROCEPHALY.

patient. Removal of the tumor is the only method by which these patients can be cured. This is possible only at times and should always be withheld as long as feasible. The simple meningoceles have by far the best prognosis. Excision of these is advisable, but should be deferred until the patient's age makes the operation less serious. Should rupture of the covering skin be imminent it can usually be prevented by transferring pressure from the affected area by means of pads, but at times excision of part or all of the sac may appear to be the only way to prevent rupture.

The successful removal of these malformations must be extremely rare. The tumors are usually large, they often contain brain substance, and they are frequently associated with hydrocephalus. It is of the utmost importance to determine the presence or the absence of hydrocephalus before attempting removal. The



occipital forms are much more frequently caused by or associated with hydrocephalus. Aspiration of a sac is useless, for the fluid returns in a few hours. Surgical procedures are not indicated in the presence of defective mentality.

**Microcephaly.**—This term is applied to a variety of conditions in which the head is abnormally small. In the vast majority of cases this is a consequence of arrested development of the brain. Instances are not uncommon of two or more cases of microcephaly among the members of one family and, indeed, the children of one sex may be microcephalic and the children of the other sex of the same family may be quite normal, thus suggesting that this abnormality is sometimes the result of a sex-linked factor of heredity. Children whose brain has been severely injured early in life may also be microcephalic, although the head is rarely very much smaller than normal in such cases. It must be kept in mind that in many children suffering from undernutrition and prolonged illnesses the sutures ossify and the fontanelles close earlier than in health. This is the result of a general retardation of bodily growth and is distinguished from true microcephaly by the fact that the ratio between the size of the head and the size of the body is unchanged.

Associated with microcephaly there is almost invariably mental deficiency, and frequently spastic diplegia. Convulsions are also very common. These symptoms exist in all possible combinations and in various degrees of severity.

The diagnosis may be made at birth in severe cases and the attempt has been made to recognize it before birth by roentgenographic studies. There is of course no treatment.

**Porencephalus.**—This is a condition in which there is a large cavity in the brain, usually opening into the ventricles or into the subarachnoid space. These types are termed respectively internal and external porencephalus. Sometimes two cavities may be found symmetrically situated, one in each hemisphere. Doubtless many different causes contribute to their formation, and the subject is rather obscure. Intra-uterine vascular lesions probably play a part, as do cerebral birth injuries and, perhaps, defects of development. Some children with porencephalus are hemiplegic and some diplegic; epilepsy and mental deficiency are common. However, astonishingly large defects may be found in children in whom no suspicion of gross brain defect was entertained. The symptoms of course depend on the location of the lesion. The diagnosis can be made in most cases by encephalogram.

**External Hydrocephalus.**—This may follow meningeal hemorrhage, pachymeningitis, or any lesion causing cerebral atrophy. Very large accumulations of fluid outside the brain are rare. The condition is seen in its most marked form associated with congenital malformations of the brain, particularly imperfect development of the hemispheres (see Fig. 121). On incising the dura mater, a few ounces, or sometimes even a pint, of fluid may escape. The convolutions are somewhat flattened, and may be greatly atrophied. Other lesions are found either in the brain or in the dura mater. External hydrocephalus may cause enlargement of the head and separation of the sutures, and in fact most of the symptoms of the internal variety; but usually the fluid merely fills the space left vacant by atrophy of the brain and there is no increase in pressure. In such conditions the term hydrocephalus is misleading. Collapse of the cortex in a case of internal hydro-



cephalus may give rise to this picture also. The diagnosis may be made by ventriculography. It can also be made by subdural puncture through the fontanel.

**Internal Hydrocephalus.**—This is the important variety, and when no qualifying term is mentioned it is this form of hydrocephalus which is usually understood. Hydrocephalus due to brain tumors or abscesses is not included in the following discussion.

*Etiology.*—It seems now established that internal hydrocephalus almost always depends upon mechanical causes. It is believed that the cerebrospinal fluid is formed



FIG. 121.—BRAIN IN EXTERNAL HYDROCEPHALUS, SHOWING IMPERFECT DEVELOPMENT OF THE HEMISPHERES.

Patient three and a half months old; head measured  $20\frac{1}{2}$  inches; increase in size, 2 inches in the six weeks before death; symptoms were typical of ordinary internal hydrocephalus. In the picture the small size of the cerebrum is best judged by comparison with the cerebellum, which is normal. The hemispheres were rudimentary; the basal ganglia were normal; the cranial cavity contained about one pint of fluid.

by the choroid plexuses in the ventricles of the brain. It flows from the lateral ventricle by way of the aqueduct into the fourth ventricle and into the cisternae of the subarachnoid space through the foramina of Luschka and Magendie. Its path then leads under the base and up over the convexity in the cortical sulci, until it is finally absorbed into the venous sinuses by way of the arachnoid villi. Hydrocephalus results whenever an obstruction occurs anywhere in this pathway causing the cerebrospinal fluid to be dammed back into the ventricles, where it accumulates under pressure.<sup>1</sup>

<sup>1</sup> Some cases have been described associated with hypertrophy of the choroid plexus, and it is thought that in these instances hydrocephalus is due to excessive secretion. Such cases are so rare as to be of no importance.



The aqueduct may be absent or excessively narrow, due in most instances to a defect of development, although it may also be occluded by the organization of an inflammatory exudate or proliferation of the subependymal glia. The foramina of Magendie and Luschka may fail to open or may be closed by meningitis. The cisternae and subarachnoid spaces may be affected by similar factors. Recent studies suggest that disease of the arachnoid villi may sometimes cause hydrocephalus.

In a large proportion of cases the disease is congenital, beginning in the later months of intra-uterine life. Syphilis is rarely responsible. Not more than 2 per cent of our cases have been syphilitic in origin. Heredity is a factor of some im-



FIG. 122.—SAGITTAL SECTION OF BRAIN OF SIX-MONTHS-OLD CHILD DYING OF HYDROCEPHALUS, SHOWING DILATED LATERAL AND THIRD VENTRICLES AND OBLITERATED AQUEDUCT OF SYLVIIUS (FROM DANDY AND BLACKFAN).

portance, as a few instances are on record where two children in the same family have been affected. The most obvious explanation seems to be that the same congenital abnormality has existed. A mild degree of hydrocephalus is sometimes seen in chondrodystrophy.

Hydrocephalus not infrequently seems to develop after successful operations upon spina bifida or encephalocele. In such an event it is possible that an inadequate meningeal absorption was compensated for by the increased area afforded by the sac of the spina bifida; when the sac is removed the absorption of fluid is no longer adequate. But probably in most of these cases the hydrocephalus was already present at the time of the operation but had not yet given signs of its presence.

*Pathology.*—Depending upon the cause and the duration of the condition the amount of fluid may be small or large. It may be only a few ounces or several pints. We have seen 1500 c.c. in an infant two weeks old and 2500 c.c. in one who



died at four months. Much larger quantities than this have been reported in children living several years. In composition the fluid resembles normal cerebrospinal fluid. Minor changes have been reported but are not uniform. The fluid may be slightly yellow and there may be an excess of cells in cases following a recent meningitis. The effusion may become purulent from accidental infection resulting from operation, from rupture, or from infection through the sac of a complicating spina bifida.

A careful search is often necessary to locate the site of obstruction. After the brain is fixed by the intracarotid injection of formalin, the injection of india ink or of some stain into the ventricles will usually reveal where the circulation has been interrupted. The aqueduct is frequently the site of the lesion. It may be repre-



FIG. 123.—OBSTRUCTIVE HYDROCEPHALUS.

Section of congenitally malformed aqueduct, showing multiple interruptions of narrow slit (from Ford).

sented by only a few scattered ependymal cells or by a few disconnected slit-like cavities. In some cases a well-formed aqueduct is outlined by ependyma, but the lumen is filled with glial tissue. The foramina of Magendie and Luschka may be absent without any other apparent changes, or the membranes in that region may be thickened and opaque, suggesting that some previous inflammatory process has sealed the openings. The cisternae may be obliterated and there may be adhesions under the base. The hypothesis of intra-uterine meningitis has been advanced to explain the obliteration of the subarachnoid channels in congenital hydrocephalus, but it seems more reasonable to assume that the splitting of the mesenchyma by which these spaces are formed was never completed. Acquired cases must be due to meningitis in almost every instance. Multiple blocks are often found.

The chief changes in the brain result from the distention of the ventricles by fluid. This continues until the hemispheres are destroyed to a greater or less extent. The convexity of the brain thus suffers most. The basal ganglia and cerebellum are



somewhat flattened but otherwise relatively normal. The progressive distention results in a gradual thinning of the brain substance which forms the ventricular



FIG. 124.—OBSTRUCTIVE HYDROCEPHALUS.

Section of well-formed aqueduct plugged by organization of inflammatory exudate in the course of a meningitis (from Ford).

walls; often these are found only one-fourth of an inch in thickness, and the cortex may be a mere shell (Fig. 126). The ependyma of the ventricle and the pia mater are at times actually in contact, all the brain tissue having been absorbed. The brain

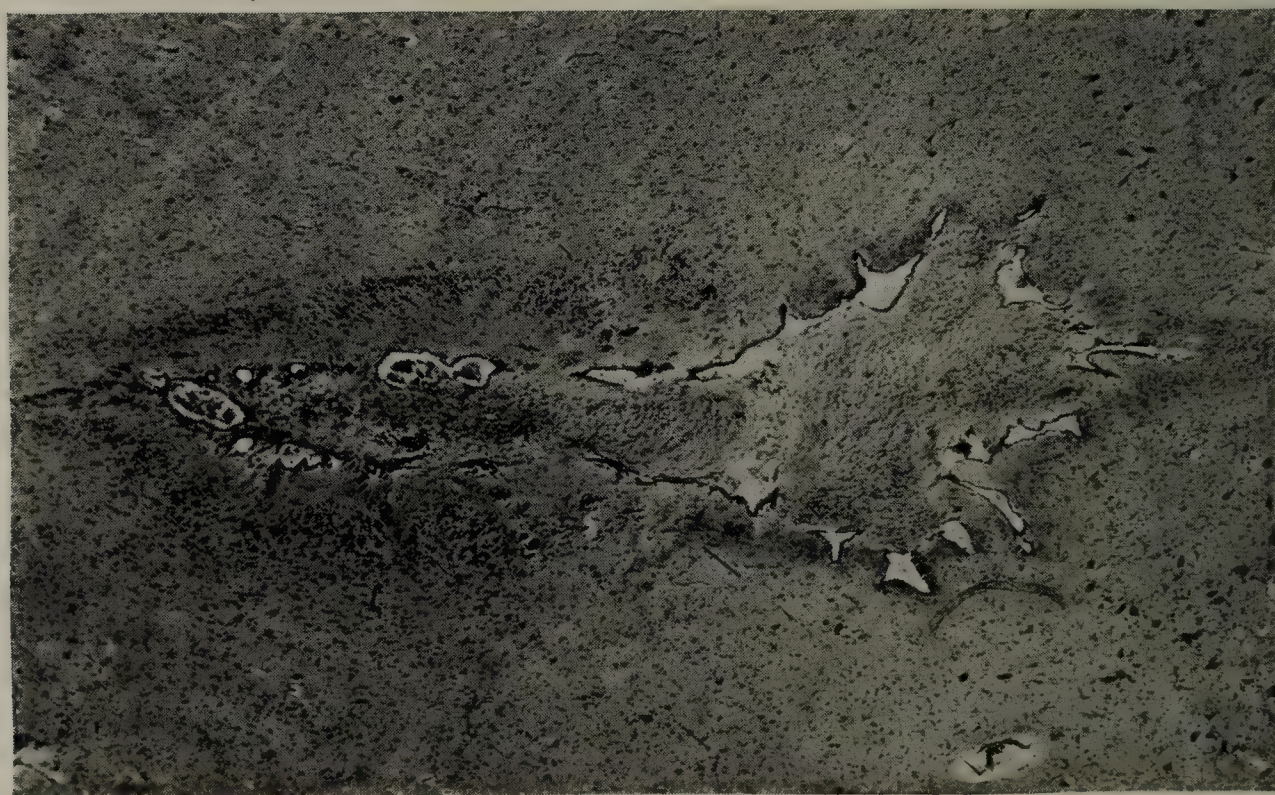


FIG. 125.—OBSTRUCTIVE HYDROCEPHALUS.

Section of well-formed aqueduct plugged by fibrous tissue probably due to organization of old intraventricular blood clot (from Ford).

in such instances resembles a large double cyst. In less marked cases there may be only a flattening of the convolutions. The foramina of Monro are dilated, and in



the communicating type the foramina of Magendie and of Luschka also. The septum lucidum is greatly thinned or only shreds may remain. The brain is anemic and the gray and white substance may be indistinguishable. The ependyma may be normal. The microscopical changes are inconstant and not marked. There is a tendency to atrophy and disappearance of the ganglion cells.

The cranium is markedly affected. The bones are often very thin; the fontanelles are large and the sutures, especially those of the vault, widely separated. There may be a formation of wormian bones. After removal of the fluid, which alone gives it configuration, the head may collapse. It should not be forgotten, however, that hydrocephalus may coexist with premature ossification, in which case the head may be small. Pressure of the fluid upon the roof of the orbit causes this

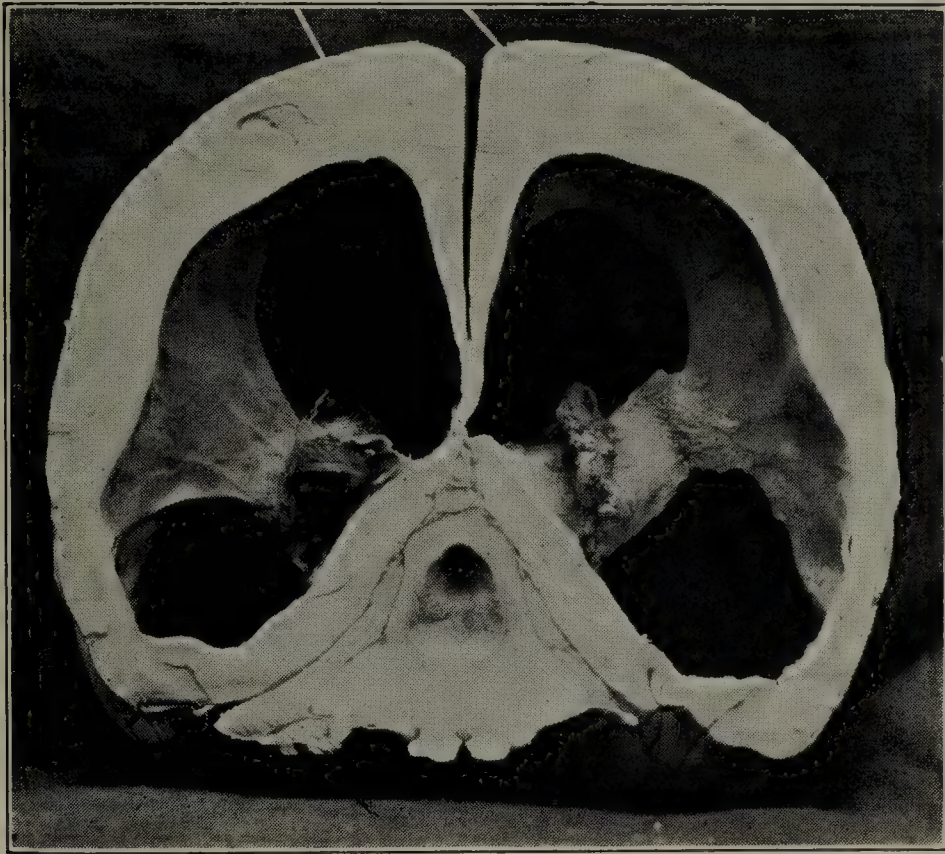


FIG. 126.—INTERNAL HYDROCEPHALUS, SHOWING DILATATION OF THE VENTRICLES AND DISTORTION OF THE CORTEX.

Child two years of age, five months after an attack of meningococcus meningitis.

to become depressed. When recovery occurs the sutures and fontanelles may close with the help of wormian bones, and irregular thickening of the bones of the skull take place. The most frequent lesion associated with congenital hydrocephalus is spina bifida and meningocele of some variety; more rarely there is encephalocele. Sometimes there are deformities in other parts of the body, such as clubfoot or harelip.

*Symptoms.*—In many cases of congenital hydrocephalus the child dies *in utero*. At other times the process may be so far advanced before birth that cesarean section or craniotomy may be necessary before delivery is possible. In perhaps the majority of cases, no symptoms are observed at birth, or the head is only slightly larger than normal. Birth injury is not uncommon. Usually, nothing is noticed until the child is two or three months old, when it is discovered that the head is increasing in size at an abnormal rate. Instead of the usual half an inch a month it may be two or three times this. If the progress is rapid, other symptoms



are soon evident—the infant cannot hold up his head, he is lethargic and all his perceptions are dulled. Only in rare cases is there blindness, but there is usually some interference with sight; this is, however, difficult to make out with young infants. Very rarely there is deafness. The pupils are usually equal, though they may be dilated. Nystagmus and convergent strabismus are often present. In severe cases the great weight of fluid distorts the roof of the orbit by pressure from above, pushing the eyes downward and causing them to protrude slightly, so that some of the sclera is visible above the cornea. This gives a characteristic expression. If the hydrocephalus has developed very rapidly, papilledema is some-

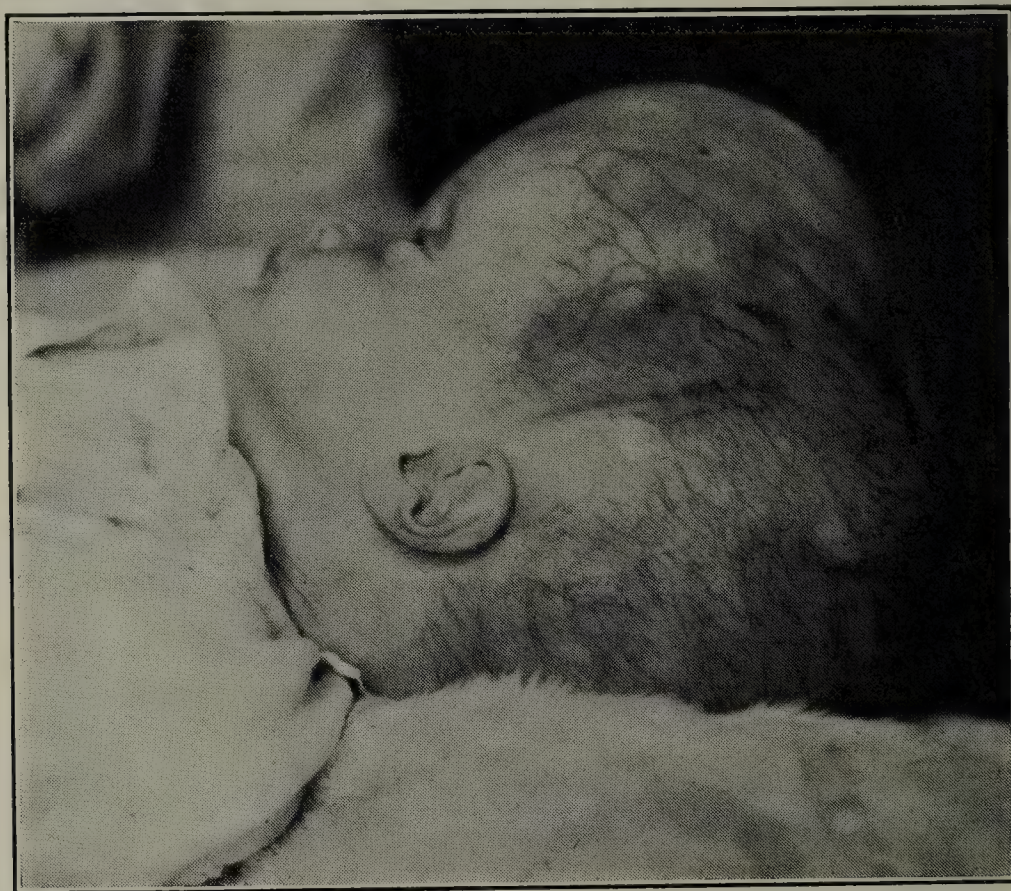


FIG. 127.—HYDROCEPHALUS, SHOWING PROMINENCE OF SCALP VEINS.

times seen. This is, however, exceptional; optic atrophy of greater or less extent is the rule.

There is usually rigidity of the muscles of the extremities, more marked in the legs. The reflexes are exaggerated.

For a time the nutrition is well maintained, but when the head enlarges markedly, the body wastes and the disproportion between the two may seem greater than it really is. Convulsions are sometimes seen. Cases which develop early and progress rapidly are usually fatal before the end of the first year, and often before six months. The causes of death are malnutrition, convulsions, and more frequently some intercurrent disease.

The cases which follow some meningeal inflammation usually develop slowly. There may be a history of frank meningococcus meningitis. Sometimes there is only a history of an unexplained fever, without symptoms to draw attention to the meninges. When the symptoms develop slowly, the head may be but little larger than normal. The surprising thing about many of these cases is that the distinctly cerebral symptoms are so few. The more readily the bones of the skull yield to pressure, the fewer are the nervous symptoms, hence, other things being



equal, they are less marked when the disease begins before the sutures are firmly ossified than in the later cases. A comparatively small amount of ventricular dilatation may cause very marked symptoms in a child two or three years old, while a much larger amount in an infant of a year may produce much less disturbance.

Even though the progress of the disease is slow the development of the patient is greatly retarded. If the course is progressive, death eventually takes place, although it may be postponed for many months. The special senses are generally not noticeably affected; but intelligence in most cases is interfered with, in some only slightly, in others very markedly, while some are idiotic. Sensation is not often affected. The course is usually a chronic one and from time to time there may be exacerbation of the symptoms.

Spontaneous arrest may occur at almost any stage. There may remain only a moderate enlargement of the head and fair or complete intelligence, or recovery may be delayed until the head has reached an enormous size, and the child, on account of this, quite unable to move. Such an outcome, however, is rare.

*Diagnosis.*—The most important symptom is the enlargement of the head, and this can only be arrived at by careful measurement and comparison with the normal size. The rapidity of growth is quite as important for diagnosis as the fact of enlargement. If the head grows as much as an inch a month there can be little doubt. The enlargement most frequently confounded with hydrocephalus is that which occurs in rickets. In the latter disease it is almost invariably irregular; there are prominences over the two frontal eminences and over the parietal bones, often with furrows between them; the size of the head is chiefly due to thickening of the bones of the skull; the marked prominence of the forehead is not seen, and the increase in the biparietal diameter is less striking; furthermore, there are other signs of rickets. A deformity of the head not unlike that of hydrocephalus occurs in many premature infants. Ylppö has shown that the ventricles are not enlarged and has suggested the term megacephalus for this condition.

Ventricular puncture reveals an excessive amount of fluid. The thickness of the cortex may be judged by the distance the needle penetrates before fluid is secured. Occasionally one is astonished to find purulent instead of clear fluid even when no fever is present. This pus is usually sterile. These are examples of low-grade infections in which the original organisms appear to have died out. Some of them occur from rupture of a brain abscess into the ventricle. Occasionally we have cultivated organisms of the colon group from such pus, which apparently has gained entrance from a low-grade umbilical infection at birth; the course of such cases differs little from ordinary hydrocephalus. Pachymeningitis hemorrhagica may be confounded with hydrocephalus; a gradual enlargement of the head occurs in this condition, and fluid is obtained in considerable quantity on puncture of the fontanel. The fluid in this condition is, however, obtained very superficially; it is reddish or reddish yellow and contains red blood cells; moreover, hemorrhages in the eyegrounds are almost constantly present.

Dandy's method of ventriculography reveals the exact contour of the ventricles and may indicate the site of obstruction. Additional information on this latter point is given by the phthalein test. The dye is injected into the ventricle, and its subsequent appearance in the spinal fluid and urine is studied. Under normal con-



ditions the dye appears in the lumbar fluid within five minutes after the injection; 15 to 20 per cent is excreted in the urine during the first two hours. With obstruction at the aqueduct or the foramina, dye does not appear in the spinal fluid, and is excreted in the urine slowly over a period of days. In communicating types of hydrocephalus, where the obstruction is at the base and the passage of fluid over the surface of the brain is impeded, dye appears promptly in the spinal fluid, but owing to poor absorption it is excreted very slowly in the urine. This type of

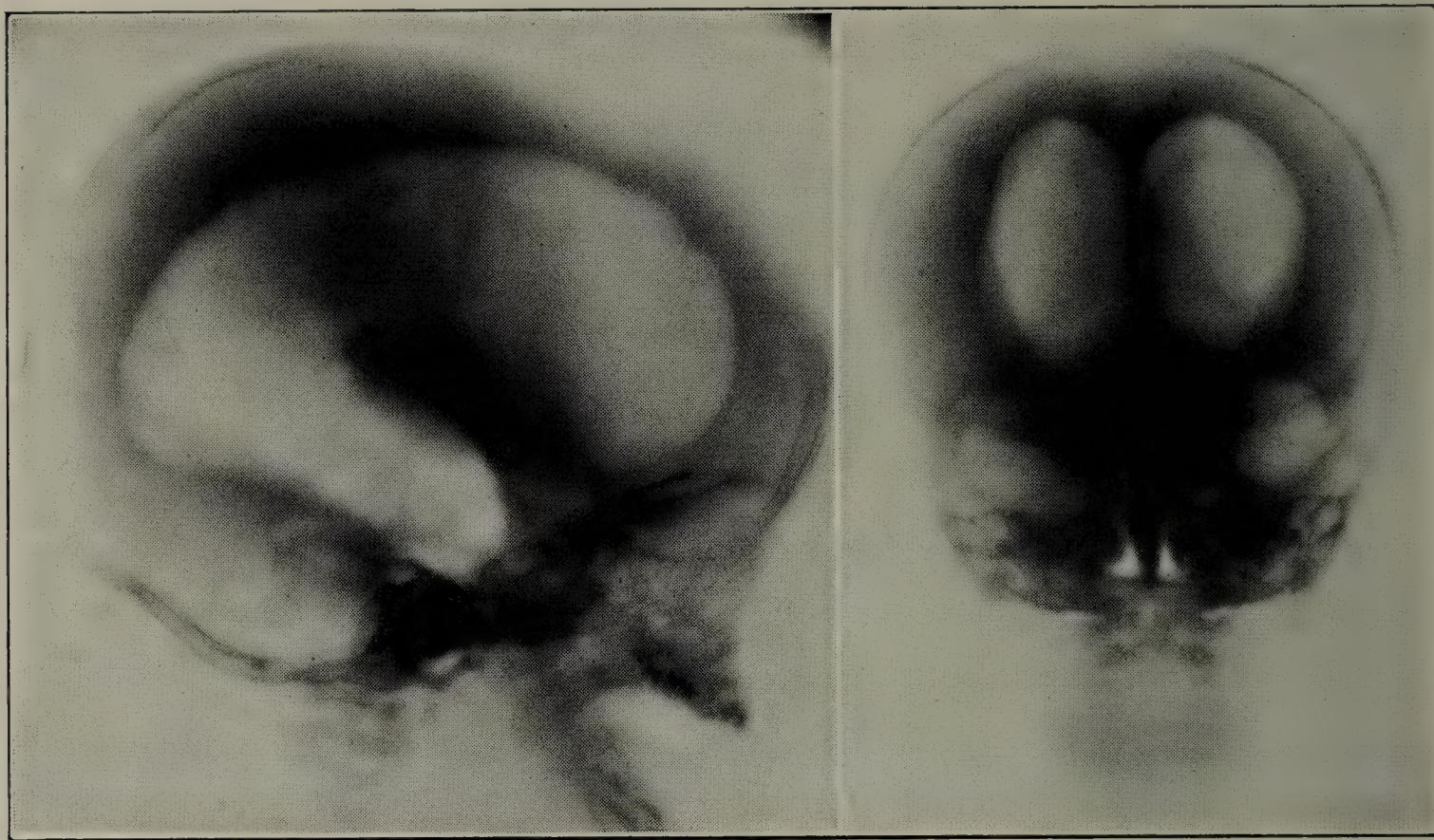


FIG. 128.—ENCEPHALOGRAM IN HYDROCEPHALUS, SHOWING OUTLINE OF THE VENTRICLES AFTER DISTENTION WITH AIR.

Robert H. (B.H. 269725), aged five and a half months. He developed meningococcus meningitis shortly before the age of four months, but the disease was not recognized for three weeks. On admission at four and a half months the diagnosis was made by lumbar puncture and serum treatment instituted. The spinal fluid subsequently became sterile and the cell count fell to 20 per c.mm. The head, however, became abnormally large (circumference of head 47 centimeters, of chest 39.5 centimeters). Phthalein injected into the lumbar subarachnoid space showed delayed absorption, only 9 per cent appearing in the urine in two hours. Encephalography (lumbar injection) showed symmetrical dilatation of the lateral ventricles; the absence of cortical digital markings suggests a subarachnoid block over the convexity of the brain. At eleven months of age the disproportionate size of the head was less conspicuous; otherwise the patient appeared to be normal, both physically and mentally.

block may also be demonstrated by injection of dye by lumbar puncture; normally 35 to 60 per cent of dye so injected is excreted in the urine in two hours; a delay indicates obstruction at the base. Rarely a certain amount of irritation seems to follow the injection of dye.

*Prognosis.*—Cases developing soon after birth and progressing rapidly are usually fatal before the end of the first year. Only occasionally does a hydrocephalic child reach the age of seven years. The process may, however, go on up to a certain age and then cease spontaneously, and the child may go through life with a head much larger than normal and usually with a somewhat impaired mental condition. In others the mentality is nearly or quite normal, and yet some muscular



weakness or even paralysis persists. This arrest of hydrocephalus is probably brought about through an adjustment by which the production of cerebrospinal fluid is diminished sufficiently so that absorption by the meninges can keep pace with it. It is possible that in some instances the obstruction is spontaneously released.

*Treatment.*—The surgical treatment of hydrocephalus is rarely successful. Removal of a part of the choroid plexus has been attempted with a view to diminishing the production of fluid. Occasional success has been achieved in the relief of obstructions, but such procedures are dangerous. Medical treatment is without benefit.

## GROSS MALFORMATIONS OF THE SPINAL CORD

Malformations of the cord are at times associated with those of the brain, and bear a certain degree of resemblance to them. (1) The cord may be absent (amyelia); this condition may exist alone or with absence of the brain. (2) The lack of development may be only partial (atelomyelia), as when some of the tracts are wanting. The most important form is defective development of the lateral tracts, which may be a cause of spastic paraplegia (Charcot). (3) There may be a malposition of some of the gray matter (heterotopia). (4) There may be a double cord (diplomyelia); the division is generally incomplete, and is attributed to an abnormal development of the central canal; it is usually associated with other deformities. All of these malformations are extremely rare and of very little practical interest.

There remains to be mentioned the only one which is really important, the type associated with spina bifida.

**Spina Bifida.**—This is a malformation of the vertebral canal with a protrusion of some part of its contents in the form of a fluid tumor. The tumor is elastic, compressible, usually increased by crying, and sometimes by pressure upon the anterior fontanel. The contained fluid is cerebrospinal fluid. It is one of the most frequent congenital deformities. In a few cases there is a history of some deformity in other members of the family. We have seen two successive children in the same family with spina bifida.

Spina bifida is due to an early failure in development—in most cases before the cord is segmented from the epiblastic layer from which it is developed. Hence it remains adherent to the epiblastic covering, and the structures which should be formed between the cord and the skin are undeveloped. For this reason there is in the wall of the sac a fusion of the elements of the cord, nerves, meninges, vertebral arches, muscles, and integument. If the error in development occurs later, the cord and nerves may be attached to the sac, but not intimately fused with it; in still other cases the cord does not enter the sac at all. The malformation may occur before the central canal is closed; or, if closed, it may reopen from the accumulation of fluid. It is probable that the accumulation of fluid occurs first, and that this prevents union of the parts of the vertebral arches.

Although the mass is generally associated with a bifid spine, this is not necessarily the case. The protrusion may take place through the intervertebral notch or foramen, or there may be a fissure of the bodies of the vertebrae, with an anterior



tumor projecting into the cavity of the thorax, abdomen, or pelvis; there may be no external tumor, a condition known as spina bifida occulta. The principal anatomical varieties are meningocele, meningomyelocele, and syringomyelocele.

*Meningocele.*—In this form there is a protrusion of the membranes only. The accumulation of fluid is either in the subdural or the subarachnoid space posterior to the cord. The opening of communication between the tumor and the spinal canal is small in this variety, usually being about one-twelfth to one-sixth of an inch in diameter. There may be no communication at all. The skin is usually fully developed. The tumor is frequently globular, sometimes pedunculated, and may attain a very large size. This is because spontaneous rupture is not likely to occur, and the tumor does not become infected except by operative interference. With such tumors patients may live to adult life. This variety is most frequently seen in the cervical region. It has the best chance of natural recovery, and in it, operation gives the best results.

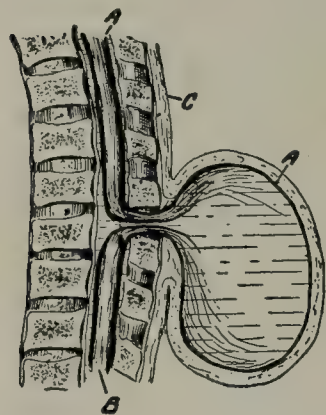


FIG. 129.—MENINGOMYELOCELE (PARTIALLY DIAGRAMMATIC).

A, the membranes; B, the cord; C, the integument. The accumulation of fluid is in front of the cord, the filaments of which are spread out, forming a part of the wall of the sac.

*Meningomyelocele.*—This is by far the most frequent variety of spina bifida. It is the form usually seen in the sacrolumbar region. The accumulation of fluid takes place in the anterior subarachnoid space, less frequently in the anterior subdural space (Fig. 129). In this form the cord is contained in the sac, and usually forms a part of its wall. The tumor is smaller than the meningocele, the usual size being that of a mandarin orange. It is sessile, never pedunculated. As a rule it is only partly covered by skin, but has a central area, usually elliptical in shape, where there is only a thin translucent membrane. This surface, which is known as the central cicatrix, is sometimes covered with granulations, and frequently ulcerates. The tumor often has a vertical furrow or a central umbilication, corresponding to the attachment of the cord on its inner surface. The usual relation of the parts is for the cord to run horizontally across the upper part of the tumor to the central cicatrix, with which it becomes

blended, and from which again the nerves arise. These reënter the canal at the lower part of the tumor, and are distributed below as usual. In other cases the cord joins the wall of the sac soon after its entrance, and its attenuated fibers are found spread out all over the sac, coming together again below and entering the spinal canal.

*Syringomyelocele.*—In this variety the accumulation of fluid is in the central canal of the cord, the lining of the sac being here the attenuated and atrophied cord elements. This is the rarest form of tumor, but the one most frequently associated with hydrocephalus, and consequently has the worst prognosis. It may be found in the dorsal or dorsolumbar region as well as in the lumbosacral.

*Spina Bifida Occulta.*—There is no tumor to be seen in this variety; there is, however, incomplete fusion of the vertebral lamina as in the other forms. In most cases the spinal cord is normal and the condition is of no clinical importance, but occasionally there is an associated myelodysplasia causing severe nervous symptoms. Frequently there is some abnormality of the overlying skin such as an



abnormal growth of hair, an area of pigmentation or even a pad of fat, and sometimes the defect in the lamina may be palpated.

*Associated Deformities.*—With spina bifida other deformities are frequently associated, the most common being clubfoot, hydrocephalus, more rarely encephalocele, cerebral meningocele and harelip. Double clubfoot is most frequently of the equinovarus type.

*Nervous Symptoms.*—Paralysis is frequent in meningocele and syringomyelocele but is not so common in meningocele. It is unusual in spina bifida occulta and when present is usually less severe than that associated with external tumors. There may be atrophy and weakness or paralysis of the calf muscles and buttocks, loss of tendon reflexes, especially the ankle jerks, clubfoot, trophic ulcers on the feet and perineum, edema, and even loss of toes. There is often partial or complete

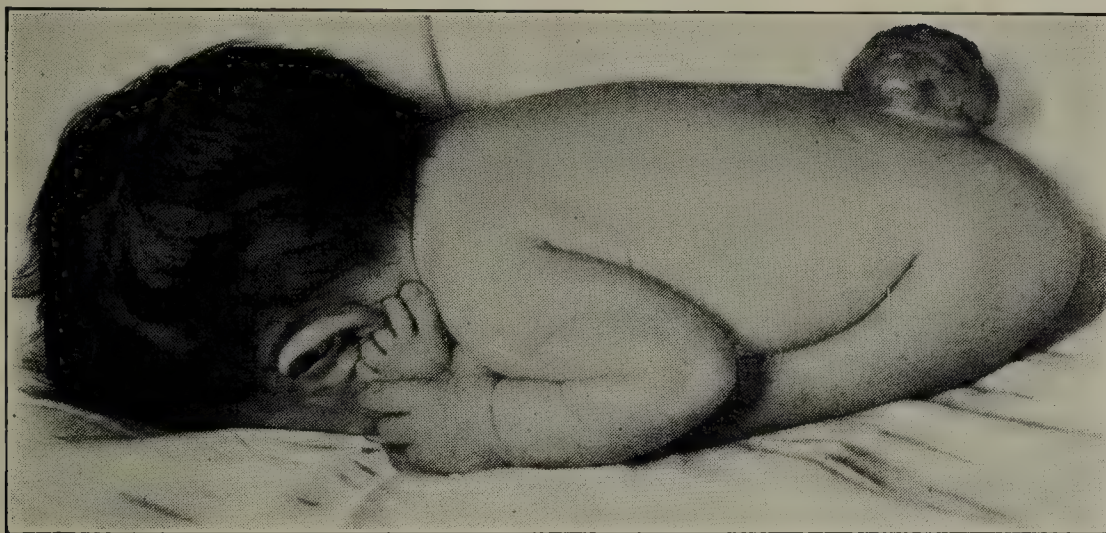


FIG. 130.—SPINA BIFIDA WITH MENINGOMYELOCELE.

Infant one month old; paralysis of both lower extremities.

loss of sphincter control. It is usual to find some anesthesia over the feet, ankles and perineum and this may be of segmental or nonsegmental distribution. The sensory loss may be dissociated as in syringomyelia. These symptoms, especially the trophic changes and deformities, may slowly increase during the course of years from traumatization of anesthetic tissues and loss of muscle balance, which accentuates the malposition of the ankles. In some instances spina bifida, especially spina bifida occulta, may be the cause of incontinence without other nervous symptoms. This condition must be sharply distinguished from the common nocturnal enuresis or occasional diurnal incontinence of functional origin; enuresis of organic nervous origin as a rule causes continuous dribbling.

In rare cases the defect may be in the cervical region and the associated paralyses will therefore be of the spastic type, with ankle clonus and positive Babinski reflexes.

*Prognosis.*—The tumor in spina bifida tends to increase in size, and if it is covered by skin its growth may be almost unlimited. It has been known to attain a circumference of twenty-two inches. If the integument is wanting and the sac wall is very thin, rupture is pretty certain to take place, either spontaneously or by some accident, in the course of a few months; usually death then results from infection. Convulsions frequently follow drainage of the cerebrospinal fluid and death from this cause may ensue. In a large number of cases death is due to



malnutrition dependent upon the associated conditions. Infection of the tumor may take place without rupture, the organisms passing through the wall of the sac. If the opening communicating with the spinal canal is small, this infection may excite an inflammation limited to the wall of the sac, and result in a complete cure of the spina bifida, usually with sloughing. We have seen a number of such cases in older children in whom this process had occurred in infancy. The site of the former tumor was marked by a large dense cicatrix, and there usually remained partial paralysis of the legs. If the opening into the spinal canal is large, inflammation of the sac is usually followed by meningitis.

Simple meningocele, when covered by integument, gives the best prognosis, and complete recovery may occur. In meningomyelocele, especially if complete paralysis exists, the prognosis is bad; and if there is also hydrocephalus, the case is hopeless. In most of the cases in which cure of the spina bifida has followed operation, hydrocephalus has subsequently developed.

*Diagnosis.*—It is usually easy to recognize spina bifida, but it is often difficult to distinguish between the different varieties. The absence of a palpable fissure in the spine and perfect translucency point strongly to meningocele. Paralysis of the sphincters and lower extremities, umbilication of the center of the tumor, a sessile tumor, a palpable bony fissure, and a large central cicatrix, point to meningomyelocele. As we have said above, an abnormal growth of hair over the sacrum, an area of pigmentation or even a pad of fat may suggest spina bifida even when a defect in the spine cannot be palpated. It must be kept in mind, however, that these appearances may exist without spina bifida. Roentgenograms will reveal the bony defects in older children. The absence of such defects rules out the diagnosis of spina bifida, but their presence does not prove that the spinal cord is defective.

*Treatment.*—In all cases the tumor should be protected from pressure, and when it is not covered by integument, care taken that the surface is kept absolutely clean and aseptic. It should be covered with some antiseptic powder and surrounded by a large pad of absorbent cotton, or a rubber ring-cushion. Complete paraplegia with involvement of the bladder and rectum, hydrocephalus, or extreme malnutrition—all contraindicate operative interference. If these are absent, operation may be considered. The time of operation will depend somewhat upon the nature of the tumor. If it is covered by integument and growing slowly, it is well to wait until the child is at least six months old. In other cases delay is dangerous, because of the liability to rupture with subsequent infection.

The usual surgical treatment is excision of the sac. For a description of this and the various plastic operations that have been proposed in connection with it the reader is referred to works on operative surgery. In operating, it should not be forgotten that in the great proportion of the cases some part of the cord is in the sac.

The immediate risk of the removal of tumors containing a large amount of fluid is considerable. Although the child may recover from the operation, recovery is often incomplete, some degree of paralysis with atrophy, contractures, and deformities remaining, because of the implication of cord elements in the sac; besides this, there is always the danger of the development of hydrocephalus.



Penfield has recently described an operation in which the sac is not excised but the meninges are folded in and the skin closed over them. He hopes in this way to preserve the absorbing surface of the sac and to prevent the development of hydrocephalus.

## CONGENITAL CEREBRAL PALSIES

There is so much difference of opinion about the classification of the infantile cerebral palsies that a satisfactory discussion becomes a matter of some difficulty. The attempt will be made in these pages to describe each clinical group in an objective manner and to give the facts bearing on etiology with little attempt at interpretation. It is not yet possible to define clearly the cerebral palsies which result from birth injury, and they must of necessity be discussed together with the prenatal conditions.

**Congenital Cerebral Diplegia.**—This syndrome is the commonest type of congenital spastic paralysis and constitutes the great bulk of the infantile cerebral palsies. In the records of the Harriet Lane Home diplegia occurs at least ten times as frequently as congenital hemiplegia. Diplegia may be defined as a condition in which there is weakness and spasticity of the extremities on both sides. There is a tendency for the distal joints of the legs to be more severely involved than the proximal joints and for the legs to be more affected than the arms. Hence, in mild cases there may be only a paraplegia, and in even milder cases merely spasticity of the calf muscles causing talipes equinus. In very severe cases all the skeletal muscles are rigid and there is often bulbar palsy as well. Such cases are indistinguishable from double hemiplegia. The tendon reflexes are increased and there is usually a double extensor response on plantar stimulation. Diplegia is associated almost invariably with some degree of mental defect, and this varies with the severity of the paralysis although notable exceptions to this rule are known. In about 35 per cent of cases there is slight microcephaly, and in a very small number this is pronounced. General convulsions occur in about 25 per cent of all cases. Flaccid or atonic types are described but are rare, and cases in which the rigidity is of the extrapyramidal or pallidal type are known. In these the exaggeration of the reflexes and extensor response are not present.

In the most severe cases the symptoms are present from the first few days of life. There may be difficulty in nursing, feeble respiration, irritability and vomiting. The rigidity of the extremities and of the neck may attract attention almost at once. In such children the general physical development is often so much impaired that the child remains small and delicate. These children are very prone to digestive disturbances and many of them die in early infancy. Their temperature regulation is also defective and they develop high fevers from mild infections. Some of them are sensitive to drugs and may develop atropine poisoning from the small amount needed to dilate the pupils. They are nearly always helpless, and no material improvement can be expected. In milder cases the early symptoms may be overlooked, especially if the mother has no other children for comparison. In such cases it is noted at the end of six or eight months that the child cannot sit up or hold up its head properly. There is a tendency to stiffen the body and throw the head backwards owing to spasm of the cervical and spinal muscles. When



the child is placed on his feet there is crossing of the legs and extension of the ankle (scissors position). Such children may learn to walk at four or five years, but always with some difficulty. Very few of them reach adult life. Those who survive have small, poorly developed legs and hips. The arms and shoulders may be well formed but the neck is usually conspicuous by its relatively greater development.

*Pathology.*—The cerebral lesions found in cases of congenital diplegia are of several types and their significance is not always clear. Such children come to

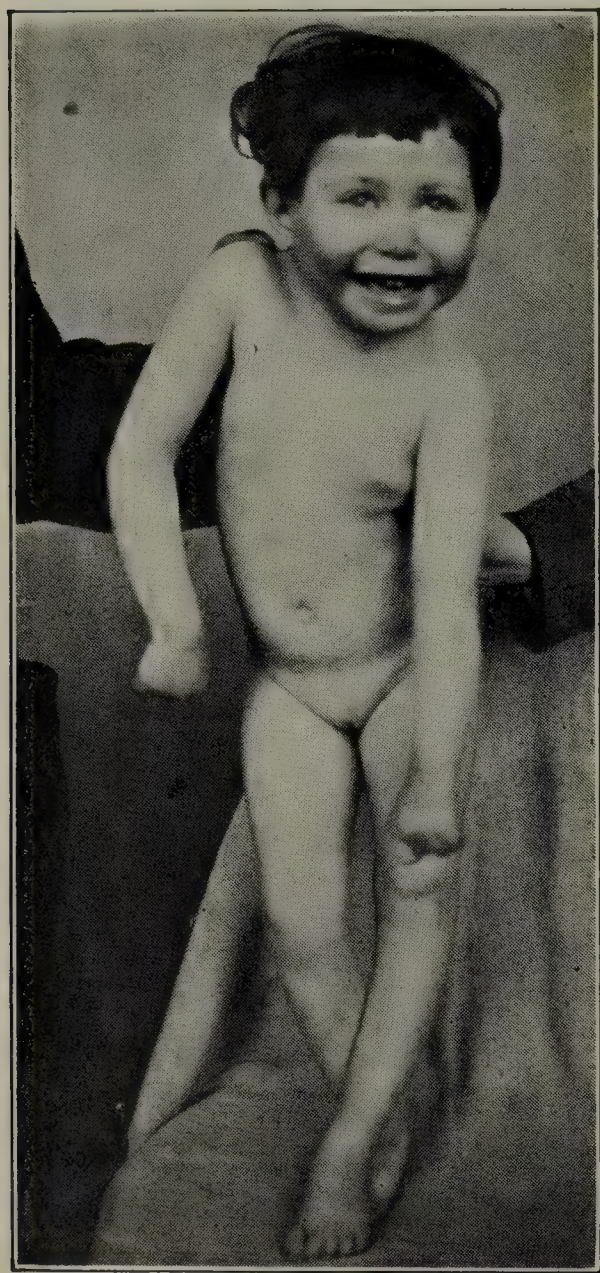


FIG. 131.—SPASTIC DIPLEGIA WITH MENTAL DEFICIENCY.

autopsy long after the active process has ceased, and end-results may give little information about the original cause. Many cases are described in which the brain was found to be of normal appearance, and only on microscopic examination was it possible to show by careful cell counts and exact measurements that the pyramidal tracts or the motor cells in the cortex were imperfectly developed. Failure of myelination of the pyramidal tracts in the lumbar cord is not an uncommon finding. Another picture is the so-called atrophic lobar sclerosis. This term is applied to a diffuse process of neuronc degeneration and reactive gliosis. The convolutions are shrunk and firmer than normal. In some places there may be small puckered scars or even cavities. The parts of the midbrain and hindbrain associated with the affected areas may fail to develop, thus indicating that the process was initiated during early fetal life. Another less common anatomical basis for diplegia is shown in those brains in which the convolutional pattern is primitive and only the primary fissures are present. Other gross malformations are sometimes found. In some cases the frontal lobes may be fused and only one ventricle present. The corpus callosum and falx may be lacking. Accumulation of fluid around the hemispheres, the so-called

external hydrocephalus, may be found. This is of course secondary to atrophy of the brain. Batten, whose exhaustive knowledge of the nervous affections of childhood enabled him to speak with authority, stated that congenital cerebral diplegia is the result of four different pathological conditions: "atrophic lobar sclerosis," arrested development of the brain, intra-uterine occlusion of the cerebral vessels and various types of meningitis. Batten and Collier maintain that "atrophic lobar sclerosis" is the most frequent anatomical basis of cerebral diplegia. In a series of cases studied by Ford, gross abnormalities of one type or another were found in approximately half of the brains examined; in the rest the macroscopic appearance was normal; in no case did the findings point indubitably to trauma at birth.



*Etiology.*—A vast difference of opinion exists in regard to the cause of cerebral diplegia. Some authors attribute the majority of cases to birth injury, particularly hemorrhage over the convexity; others consider that developmental defects are almost invariably responsible. The pathologic anatomy seems to offer the most substantial evidence bearing on this problem. The lesions actually found are very hard to reconcile with the theory of birth injury and seem to indicate defects of development and intra-uterine degenerative processes, although the interpretation of even the pathological data is not always quite clear.

The history of birth is of great interest in this connection. In an analysis of 235 cases of congenital diplegia examined in the Harriet Lane Home, abnormalities of labor such as prolonged or difficult labor and forceps or breech delivery occurred in only about 15 per cent; convulsions soon after birth in 16 per cent, cyanosis and feeble breathing in 32 per cent, and prematurity, which may be considered to favor birth injury, in 33 per cent. Similar figures have been obtained in other studies. In the interpretation of these figures it must be kept in mind that some symptoms at birth may be due to a defective nervous system and not to injury.

*Diagnosis.*—In some cases the diagnosis is a matter of difficulty, for although this is a congenital condition the symptoms are not evident until many months after birth and the parents often insist that a trivial injury or some infantile illness is to blame. Progressive cerebral degenerations or postnatal progressive diplegias may give rise to identical syndromes and can be recognized only by keeping the child under observation until the progressive nature of the disease is clear. The various types of encephalomyelitis following acute infectious diseases such as measles may be distinguished by the acute onset and the relation to the infection. Epidemic encephalitis rarely causes much spasticity but may be confused with atypical congenital diplegias if, as not infrequently happens, the somnolence and other characteristic features of the early stage are lacking. In most of these cases a careful history will reveal sleep reversal, personality changes, or other symptoms typical of epidemic encephalitis, or further observation will discover the development of Parkinson's syndrome.

*Treatment.*—The course and the result of cerebral paralysis depend upon the extent of the injury to the brain, its nature, and the age at which it is inflicted—all these being conditions which are beyond the power of the physician to modify or control. The treatment of cerebral palsy is therefore extremely unsatisfactory. Something can, however, be done for the deformities and complications. Much can be accomplished in an educational way for the mental derangements resulting from cerebral palsy. Many of the deformities may be prevented by early orthopedic treatment. Serious deformities in old cases may be greatly benefited by tenotomy or myotomy, followed by suitable muscle training. Speech training may result in some success. Operations upon the brain in old cases of cerebral palsy have been in our experience most unsatisfactory. We have yet to see one of these patients whose condition was in any important way improved by operation. Epilepsy is to be treated symptomatically.

**Congenital Double Athetosis and Chorea.**—These conditions are closely related to the congenital diplegias, and, indeed, choreo-athetoid movements are often present to some degree in the spastic diplegics. The early history is the



same in both groups. Rigidity and delay in the acquisition of motor functions may be noted early in life and the involuntary movements may not become evident until many months later. Athetosis, or mobile spasm, may be defined as a disorder of motility in which there are slow, twisting, writhing movements of the limbs, and more especially of the fingers, which are provoked by voluntary effort or by emotion. There is usually a variable increase in muscle tone. The voice has a jerky character due to involvement of the respiratory muscles, and articulation and deglutition may be defective. Facial grimaces are often very distressing. Mental development is usually below par. This condition is not progressive and may even admit of some improvement. The lesions have been studied by the Vogts and are described under the name *état marbré*. The lenticular nuclei present a mottled appearance due to the replacement of small areas of nerve cells by a dense mesh of fine medullated fibers filling the spaces between islands of normal tissue. This condition has been found at birth and is regarded as a defect of development.

Congenital chorea is closely related to athetosis and, indeed, there are transitional cases. The movements are not usually identical with those of Sydenham's chorea but are of the same general type and also associated with hypotonus of the muscles. Autopsy has been secured on two children with congenital chorea at the Johns Hopkins Hospital and in each case there were found large grayish nodules in the lenticular nuclei which were composed of masses of bipolar nerve cells of embryonic appearance.

**Congenital Hemiplegias and Cerebral Monoplegias.**—A small number of congenital hemiplegias are seen in children's clinics. These are usually not recognized until relatively late in infancy, rarely before six or eight months. The arm is always more affected than the leg; and although the child can always walk with a hemiplegic gait, it is rare for any useful function of the hand to be developed. The hand is always smaller than normal, and contracture of the flexors of the fingers and wrist usually develops. Focal convulsions are present in almost half of the cases. Mental development is almost always below normal but the degree of defect is usually less than in the diplegias. In some cases there is athetosis in the affected arm. Aphasia and hemianopia may occur. A history indicative of birth injury is secured in the majority of this group. Nine children with congenital hemiplegia observed at the Harriet Lane Home have come to autopsy. In 3 there was a large cavity in the cortex, in 3 focal cortical scars, and in 3 there were focal cortical scars with evidences of old subdural hematoma as well. Batten believed that congenital hemiplegias are due to three different causes: birth injury, unilateral arrest of development, and occlusion of the cerebral vessels *in utero*. The last two must be very rare. The prognosis is poor and some disability usually persists. Treatment is identical with that of other spastic paralysis.

**Congenital Ataxias and Tremors.**—In addition to the congenital spastic paralyses mentioned above, which are relatively common, there are a great variety of other defects of the nervous system, some of which deserve mention. Congenital ataxias of cerebellar type are known, and indeed there may be ataxia combined with spasticity in diplegia. In these cases the cerebellum may be hypoplastic or even absent. Congenital tremors of various types are recognized. These may



resemble the tremor of rest or may be increased on voluntary movement, as is true of the so-called intention tremor.

## MENTAL DEFICIENCY

By mental deficiency is meant any interference with intelligence or limitation in the adaptation of the child to his environment. Interference with intelligence may occur in children as the result of various general diseases or from organic disease of the nervous system, such as hydrocephalus, chronic meningitis, syphilis, and meningeal hemorrhage. The present chapter will treat only of mental deficiency as an apparently primary condition.

**Simple Mental Defects.**—Of all the factors that operate to produce this type of mental deficiency, heredity is the most important. This statement does not require substantiation. It is generally recognized. The descendants of mental defectives may be normal, they may be so defective that it is readily appreciable in the first year or two, or the disturbance of mentality may be so slight that it can be recognized only after several years of life. The influence of parental alcoholism, especially chronic alcoholism, has been much discussed and there is a wide difference of opinion in regard to it. It seems to us that it is a factor of some importance; but it certainly does not have the influence that has been ascribed to it by many.

The changes to be found in the brains of defectives are of all degrees of severity. Both cerebral hemispheres may be small and imperfectly developed. There may be atrophy of one or more portions of the brain, failure of development of one hemisphere, poorly developed convolutions and shallow sulci. In certain cases no changes are to be made out macroscopically, but practically all observers have found, as did Hammarberg, that even when no gross alteration was apparent the ganglion cells were infrequent and poorly developed. Microcephalus is not uncommon, and all grades are seen.

There may be all grades of mental deficiency. It is usual in this country to separate mentally defective children into three groups: (1) the *idiots*, those that never develop beyond the mental age of an average child of two years; (2) the *imbeciles*, those that never acquire a higher degree of mentality than the average child of seven, and (3) the *morons*, who do not acquire a higher degree of mentality than children of twelve.

It is frequently necessary for the physician to determine whether or not a child is mentally deficient. In doing so it should be remembered that normal development is closely dependent upon physical development; but it does not necessarily go on with equal rapidity. If an infant has been premature or badly nourished for many months or has suffered from some very severe illness, he may at the end of a year show no more mental development than an average child of six or eight months. Yet, with improvement in his physical condition his mental condition also improves so that eventually the normal is reached. There is a wide variation also in the rapidity of development of normal children. Some are quite slow, especially in certain families. Proper attention should be paid to this fact and too much emphasis should not be placed upon slight deviations from the normal. The abnormal infant is distinguished not by slight, but by gross, deviation from the normal.



A high degree of mental deficiency can usually be recognized very early; the lesser degrees require longer observation. Even those children who are only slightly affected often give some definite evidence of it during infancy. Their mental development begins late and usually ends early. It is fair to assume that those whose mental development, in the absence of sufficient physical cause, is abnormally delayed, will suffer some permanent impairment of the mental faculties; but owing to individual differences, it is impossible to predict closely the final outcome.

To appreciate the abnormal, one must be familiar with the mental and physical development of normal children. Mental development shows itself in the early months of life chiefly by the acquisition of the ability to do certain physical things. The normal child about the third month begins to grasp objects, at the fourth month he recognizes people, between the third and fifth months he holds his head up firmly, at the fifth month he reaches for things, holds them in his hands and observes them. From seven to nine months, he sits alone, and laughs in play. From nine to ten months, many children stand. At a year they often begin to walk and to repeat single words. The mentally deficient child, on the other hand, may not even hold his head up at the end of a year. He makes no attempt to grasp objects, perhaps holds them for only a moment and then drops them. He cannot sit alone, he does not attempt to stand, and does not recognize people until perhaps the end of the second year or very much later.

Some mentally deficient children are exceedingly placid; others cry continually without apparent cause and are often exceedingly restless. The expression of the normal child is intelligent, bright and alert; the abnormal child, in contrast, may betray his lack of mental capacity by his vacant, stupid expression, his open mouth, protruding tongue, drooling, and his irregular, aimless movements of the hands. As time goes on, mentally deficient children not only remain backward in things that they should do, but they also do things that normal children should not do. They develop screaming attacks, they throw their heads backward or arch and stiffen their bodies. Strabismus is often present and there may be ill-defined attacks of a convulsive nature, or typical convulsions.

It may be exceedingly difficult at times to differentiate between the merely backward child and the mentally deficient. The backward child is usually distinguished chiefly by the things which he does not do. He does not show an abnormal mentality. Children merely backward as the result of disease may not be able to talk until two and a half years old or may not walk until after that time, yet may understand what is said and done for them; their expression is normal; they seem bright, and the development, although slow, is steady and progressive. Mentally deficient children, on the other hand, are not only very backward, but they usually reach the end of their development fairly early and it is not a complete development. As Scholz says, "the mentally deficient child of twelve is not a normal child of six; he is not merely a dwarf, but a cripple." This becomes increasingly evident as the defective child becomes older and his character and mental processes find better expression. He may be disobedient, unruly, untrustworthy, cruel to animals and playmates, not interested in the play of children, and may not conform to the ordinary standards of cleanliness and neatness. Most of these children are clumsy in their movements and especially not dexterous with



their hands. There are many, however, that are docile, kind and affectionate, but whose faculties are totally inadequate when compared with those of the average child. One with experience in testing mentally deficient children is able to tell with a considerable measure of accuracy what their mental capacity is. This is accomplished by observation and various tests. The methods devised by Gesell and by Bühler have made it possible to standardize even young infants with a reasonable degree of accuracy. With older children the Binet-Simon test with various modifications has for many years been an accepted procedure. This standardizing need not concern us here; but all physicians should be in a position to recognize the abnormal. The standardization of the abnormal and particularly their training should be in the hands of experts in that field.

Partial mental defects are also known. Some children cannot learn to read and write, although intellectual development is normal in other respects and their intelligence quotient is not reduced. The term "congenital word blindness" is applied to such cases. In other children the defect is most evident in social adaptation. They are incorrigible thieves and liars. Mental development may be normal or even precocious. These children are the chief problems of the juvenile courts and often become criminals. They are often called moral imbeciles.

*Treatment.*—For the more pronounced grades of mental deficiency institutional care is advisable; for milder ones this is not necessary. The line between the normal and the abnormal is of course not a sharp one.

The problem in handling children of limited mentality consists in adapting their environment to their capacity. To try to force such a child to live up to normal average standards often brings about disastrous results. The inevitable failure and resulting tension usually find expression in behavior difficulties of one type or another. On the other hand, if the tasks set for a child are within his ability such tension is avoided and a fuller development of the individual usually takes place. Fortunately this is becoming generally appreciated, as is indicated by the organization of special classes for backward children and the development of a more tolerant attitude in the home.

**Mongolian Idiocy.**—A form of congenital mental deficiency that can be at once recognized by the physical characteristics of the child is the so-called Mongolian idiocy. The cause of this is obscure. It cannot be shown that it is due in any way to syphilis or to the excessive use of alcohol in the parents. A familial incidence cannot be traced. The condition is probably not hereditary; we know of an instance in which a woman who was a typical Mongolian idiot gave birth to two normal children. Mongolian idiocy appears with equal frequency in the two sexes. It is found in the Caucasian race and we have seen several instances in the colored. It has also been reported among the Mongolian race. A factor of great importance seems to be the age of the mother. Sometimes these children are the first-born of young mothers. Often they are the result of the last pregnancy after the birth of normal children. Most Mongolian idiots, however, are born to women over thirty-five. It is evident that the reproductive function has an important bearing upon their occurrence. They are probably the result of incomplete or inhibited development.

This is one of the common forms of mental defect—apparently more frequent



in England and in this country than elsewhere, perhaps on account of closer observation, the result of the frequent attention that has been called to it.

Pathologically, the brain is, as a rule, small. The convolutions are poorly developed and there is apt to be an aplasia of some parts, such as the cerebellum, pons or medulla. The cortex is frequently thin and the ganglion cells few in number, with rather scanty cell processes.



FIG. 132.—MONGOLIAN IDIOT.

Girl four years of age; showing hyperextension of fingers.

The appearance of these children is very striking (Figs. 132 and 133) and it can at once be seen whence they have derived their name. There is a peculiar Mongolian type of countenance; the eyes are set close together, they are slanting and the palpebral fissures are narrow. Frequently there is epicanthus. The head is brachycephalic and small. At twelve months it is often two inches below the average in circumference. The children are short for their age. Their hands are



short and thick, especially the fingers; the little finger not uncommonly is so short that it does not reach to the last interphalangeal joint of the ring finger. The muscles are poorly developed, and there is a great relaxation of the ligaments, so that the strangest and most uncomfortable-looking positions can be assumed at will and often by preference. The tongue is usually prominent, slightly protruding and deeply fissured. There is usually drooling from the mouth and often a nasal discharge, so that the lips may be greatly excoriated. Mouth-breathing is nearly always present. The rhinopharynx is often small, sometimes owing to backward projection of the vomer, sometimes to a forward projection of the bodies of the cervical vertebrae. A very moderate amount of adenoid tissue may produce marked symptoms of nasal obstruction. The expression is often that of a child suffering from large adenoid growths, and sometimes the early cases are passed over as simply "adenoids with mental dullness." Other defects are often associated. The ears are frequently misshapen; congenital malformations of the heart are quite common; in one of our cases there was absence of the patella.

Mongolian idiots are very backward in development. They frequently do not hold up their heads until one year of age or later, and may not walk until the end of the second or third year. Speech is greatly delayed and seldom normal, although almost all, if they live sufficiently long, do eventually talk to a certain extent. These children have but little resistance to any acute disease. They are particularly susceptible to infection, and the majority die in infancy or early childhood. We see many of them as infants and few after the eighth or tenth year. They succumb chiefly to pulmonary infections or to tuberculosis. There is a certain degree of variation in their mental capacity, but it is singularly slight, and, as the majority of them look much alike, so also their mental processes are alike, and very few of them reach a higher mental development than that represented by a normal child of five years. They are restless, inattentive, and can be taught only with great difficulty. Unlike certain other mental defectives the Mongol is not ill-natured and destructive; it is seldom necessary to segregate him from normal children.

The diagnosis can usually be made at birth, a fact which is attested to by the Chinese or Japanese names which these children are not infrequently given. Cretinism is occasionally confused with Mongolian idiocy; the differential diagnosis is discussed under that condition.

**Tuberose Sclerosis (Epiloia).**—This is a rare condition affecting two or more siblings. It is characterized by mental defect of various grades, epileptic convulsions, and by a skin condition termed adenoma sebaceum. The convulsions



FIG. 133.—MONGOLIAN IDIOT FIVE YEARS OLD.



usually develop in infancy and resemble the common epileptic fits. Both major and minor seizures are usual. The mental defect is generally of a severe nature and in most cases runs a progressive course. The skin lesions are first seen at about the fourth or fifth year as small pink papules on the face, chiefly over the upper lips and bridge of the nose, the so-called butterfly distribution. These papules slowly grow darker and later may be deep brown.

The brain contains many small firm tumor masses which are chiefly in the cortex but may be found in all parts of the cerebrum. They often project into the ventricles. Under the microscope these tumors are seen to be composed of giant glial cells. There is also degeneration of the nerve cells and fibers and even cystic degeneration producing small cavities. Malformations of the cortex are common. There are sometimes rhabdomyomata of the heart and teratomata of the kidneys. The papules in the skin are due to adenomata of the sebaceous glands.

### CONGENITAL INTRACRANIAL ANEURYSM

This condition, formerly believed to be quite rare, has recently been shown to be surprisingly common. In a series of 5432 consecutive autopsies at a London hospital they were found in 40 instances. Most of these do not rupture and rarely cause any symptoms. The lesion consists of a small saccular dilatation of the walls of an artery, usually arising at a bifurcation; the circle of Willis is by far the most common site. Microscopic examination reveals no evidence of atheroma or inflammation. The condition is apparently due to weakness of the muscular and elastic tissue of the arterial wall; the media is narrow and fibrous; elastic tissue is often completely absent.

The symptoms may be described under two heads: those due to local pressure of the tumor and those due to leakage of blood. The former may be lacking or there may be signs of involvement of several cranial nerves, especially the second, third, fourth and sixth. Leakage is indicated by sudden severe pain in the occiput and neck, vomiting, loss of consciousness, cervical rigidity and Kernig's sign. There is a slow pulse and possibly slight fever. The retinal vessels are engorged and may show small hemorrhages along their course. Large subhyaloid hemorrhages may cover the optic disks. The aneurysm may rupture into the cortex and cause hemiplegia and other cerebral symptoms. Several leaks may occur before one is fatal. The diagnosis depends on the presence of altered blood in the spinal fluid. This does not clot, and when allowed to stand the supernatant fluid is yellow or orange. The fluid usually contains an increased proportion of white cells as compared with the blood. The condition may be confused with pachymeningitis. The onset of the latter disease is, however, less acute. In pachymeningitis a large quantity of blood or blood-stained fluid is found in the subdural and sometimes in the subarachnoid space.

A rare but interesting type has been described recently which is associated with congenital coarctation of the aorta and is attributed to the overloading of the cerebral circulation which results from that condition. Saccular aneurysms also result from the impaction of an infected embolus in bacterial endocarditis.

*Arteriovenous fistulae* may be traumatic or spontaneous. In the latter case they probably develop from congenital malformations of the capillary beds. Their



symptoms include signs of increased intracranial pressure, dilatation of the veins of the scalp, signs of cortical irritation and a loud systolic bruit over the skull. The commonest traumatic type is due to fracture of the base causing communication between the internal carotid artery and the cavernous sinus with pulsating exophthalmos, edema of the orbit, ophthalmoplegia and a loud bruit.

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## CHAPTER CXIII

### TRAUMATIC CONDITIONS

#### CEREBRAL BIRTH INJURIES

**Incidence.**—It is well known that intracranial hemorrhage is one of the most important causes of mortality in the first two weeks of life. Autopsies on stillborn infants and those dying within two weeks of birth reveal evidences of intracranial birth injury in a very large number of cases, at least 30 per cent. There is also some evidence that intracranial bleeding is not infrequent in infants who seem quite healthy. Thus, Roberts reports that in a study of the spinal fluid of 423 newly born infants he found blood in 60. Only 26 of these infants, however, showed any clinical evidence of birth injury. Similar results have been obtained by other investigators. The value of such studies depends on the care which is taken to distinguish between blood already present in the subarachnoid space and blood drawn by the needle.

**Etiology.**—It is generally accepted today that trauma is of paramount importance among the causes of cerebral birth injury. Prolonged labor with extreme molding of the head, abnormal presentations, breech deliveries or the brutal use of forceps—indeed, any factor which increases or prolongs the pressure on the head—increases the likelihood of injury. Contracted pelves are often to blame. However, intracranial hemorrhage may also occur in infants born by normal, easy labor and even when cesarean section is performed before the beginning of labor. Prematurity is certainly a contributing factor, for the skulls of immature infants are fragile and their blood vessels delicate and easily ruptured. Post-term babies and hydrocephalics are subject to injury because of their large heads. Hemorrhagic disease of the newly born and asphyxia may also be considered contributing causes.

**Pathology.**—A large variety of lesions have been described, but venous hemorrhages are most common. They may be large or small and either multiple or single. They are in most cases limited to the surface of the brain and meninges, but may also occur in the ventricular system or even in the substance of the brain. Hemorrhages over the cortex may rupture into the brain or cause softening by compression. At the base the subarachnoid spaces are larger, and diffusion takes place more readily. Bleeding here is not apt to cause focal lesions but may cause death from increase of intracranial pressure. The dural septa may be stretched and torn. In fact, rupture of the tentorium from excessive molding is very frequent. The falx is torn more rarely. These lesions are due to lateral compression of the head, causing the vertex to rise and consequently producing excessive stretching of the falx and tentorium. Fractures of the base may result in injury to the cranial nerves. Depressed fractures may cause lacerations and softening of the cortex and extradural hematoma. Cerebral concussion and edema



may result from compression and molding. Multiple petechial hemorrhages are attributed to asphyxia. Hemorrhages into the retina are said to be found frequently if the fundi are examined, and hemorrhages into the inner ear are described.

Capon gives the following table of lesions found in 80 stillborn babies.

1. Small vessels coursing along the fibers of the tentorium may be torn; the blood then collects in a film upon the upper surface of the cerebellum or upon the upper tentorial surface, draining posteriorly around the occipital lobes.

2. The vena magna Galeni, which is frequently distorted during molding of the head, may rupture at the point where the straight sinus is formed. The blood collects posterior to the mesencephalon and drains downwards around the cerebellum, pons and medulla.

3. Cerebellar veins, near their terminations in the superior longitudinal sinus, may be injured. The effused blood flows downwards in the subdural space. Usually the hemorrhage is unilateral, but sometimes it is bilateral.

4. Hemorrhages from the superior longitudinal sinus, transverse sinus, and straight sinus are found only in the most severe types of birth injury. The infant is almost invariably stillborn.

5. The internal cerebral veins, for instance the choroidal veins, may be damaged. These examples are rare and are found almost exclusively in stillborn premature infants. The blood collection may occupy the lateral, third and fourth ventricles; blood is also frequently found within the spinal membranes in these cases.

Schwartz has shown that areas of necrosis are sometimes found under the ependyma of the lateral ventricles, which later result in periventricular cavities (central porencephalus). These he attributes to disturbances in the circulation of the vein of Galen and its tributaries.

**Symptoms.**—If the hemorrhage is large, the child is usually stillborn, although fetal movements may have been active up to the commencement of labor. When the injury is not so severe as to be immediately fatal, the child may be born deeply asphyxiated and respiration may be established only after considerable effort. Symptoms of birth injury may be present immediately after birth or may appear after an interval of several days. The commonest picture includes cervical rigidity, cyanosis, failure to nurse, feeble cry, bulging of fontanel and irritability. Intermittent cyanosis is very characteristic. Convulsions are common. The knee jerks may be increased. Opisthotonos is often present, also rigidity of the extremities, clenching of the hands and automatic movements. Respiration may be slow or irregular. The pulse may be slow or rapid. There may be nystagmus and even slight exophthalmos. Retinal hemorrhages are common and the retinal veins may be engorged, but papilledema is rare. In other infants there may be flaccidity in place of rigidity, pallor in place of cyanosis, and apathy in place of irritability. The term *asphyxia pallida* has been applied to this condition in the past. Recently Munro has claimed that it is in reality due to surgical shock, and that it is the result of severe cranial or intracranial injury.

In large hemorrhages at the base convulsions are rare and death occurs within a few days. In hemorrhages above the tentorium convulsions are more common and the danger to life is less. Rigidity usually results from irritation of the meninges by subarachnoid hemorrhage. Paralysis are not present, for the motor activities of the newly born are all reflexes mediated by the brain stem and spinal



cord. The cerebral motor centers have some degree of irritability, however, as shown by convulsions and twitchings.

**Diagnosis.**—The presence of intracranial hemorrhage may be obvious when the typical symptoms are all present: convulsions, cyanosis, rigidity, coma and a bulging fontanel. When clinical manifestations are less pronounced, its recognition may be extremely difficult. In the newly born infant *asphyxia* during labor may produce similar symptoms; but bulging fontanel and focal nervous symptoms do not occur, and the spinal fluid is normal. *Congenital atelectasis* may cause continuous or intermittent cyanosis and even convulsions; the x-ray may be of assistance here. The somnolence of the normal infant during the first twenty-four hours of life often causes much concern in the belief that this is due to intracranial hemorrhage. Although the majority of intracranial injuries declare themselves at an early date, it is possible for considerable injury to occur without early symptoms, particularly if the brain stem is not involved.

Examination of the spinal fluid may be of considerable help; if delayed for a day or more any blood present will be altered and consequently distinguishable from that produced by pricking a vein. In the latter case the fluid is usually streaked with blood and gradually clears as it flows. The red cells are not crenated, there is no excess of white cells, and when centrifugalized the supernatant fluid is clear and gives a negative benzidine reaction. If much blood is present a clot will form. If the blood has been in the subarachnoid space for some hours before spinal puncture, the fluid is uniformly colored, the red cells are crenated and there is an excess of white cells; the supernatant fluid is yellow and the benzidine test is positive until the hemoglobin has been converted into bile pigments, which in most cases requires several days. Subsequently the direct Van den Bergh reaction often becomes positive. This type of fluid does not clot. The spinal fluid may give unmistakable evidence that a hemorrhage has occurred, but a colorless fluid does not rule out this condition, nor does a xanthochromic fluid indicate gross hemorrhage. Such fluids have been found in infants with no trace of intracranial hemorrhage at autopsy. The explanations offered are: (1) that minute hemorrhages actually have occurred and have left no anatomical trace; (2) that bile pigment has found its way from the blood stream. At this time of life the blood plasma is particularly rich in bilirubin (*cf.* Physiological Jaundice). Glaser has recently described a "physiological xanthochromia" occurring in normal newly born infants, and especially in premature infants, in which the pigment gave neither the tests for hemoglobin nor bilirubin; spectroscopic examinations were not made. Until further light is thrown upon this pigment, its nature must remain obscure. Some authors believe that the determination of the spinal fluid pressure is important, but accurate readings are so difficult to obtain at this age that the test is of little clinical value.

**Late Results.**—We have observed only a few children with permanent disability in whom the diagnosis of birth injury was fully established at birth. Some of them have been followed for over five years and several postmortem examinations have been secured. The clinical symptoms are neither uniform nor characteristic. The commonest syndrome is hemiplegia with spasticity, mild mental defect and often focal or general convulsions. Monoplegias are also not infrequent. Cases



of bilateral spastic paralysis also occur and are sometimes indistinguishable from the congenital diplegias described elsewhere, but these are not so common as the unilateral palsies. Some authors ascribe extrapyramidal syndromes to birth injury and include athetosis, chorea and dystonic syndromes in this group. Mental defect without disturbance of motility is also described. Many of these children show slight enlargement of the head for some months after birth, and there is evidence that hydrocephalus may in rare instances result from birth injury. The claim has been made that hemorrhagic pachymeningitis, which becomes evident later in infancy, may develop on the basis of a birth injury.

Lesions found months or years after birth include cortical scars and cysts with thickening and often pigmentation of the overlying meninges. Central paraventricular cavities are also described.

**Treatment.**—There is no general agreement about the proper treatment of intracranial birth injury. The usual plan is to perform repeated spinal punctures so long as there is any evidence of increased pressure. This method at least serves to aid in the removal of blood and to reduce the intracranial pressure. In the common meningeal hemorrhage it is the logical treatment. The element of shock must be taken into account as well as that of pressure. This is especially important in the children with “pallid asphyxia.” These children should be handled as little as possible, should be kept warm and should be given fluids by a medicine dropper. Munro warns against morphine. In cases in which there is evidence of hemorrhagic disease of the newborn, transfusion or the intramuscular injection of blood is indicated. Encapsulated hematoma compressing the cortex have been removed with good effects, but it is rarely possible to establish such a diagnosis and the mortality is so high that operation is seldom justified. In general, conservative treatment is to be preferred.

The spastic paralyses which result from birth injury are treated in the same way as similar conditions due to other causes. Craniotomy is, of course, useless. Special exercises, muscle training, massage, tenotomies and the Stoffel operation are all employed with some success. Epilepsy is treated as described in the section devoted to that subject. In some cases of focal epilepsy, operation for removal of the cortical scar has given good results, but this is not the rule and in most cases little can be expected from surgery. Mental defectives should be graded by psychiatric examination and, if intelligence is sufficient, should be given proper training so as to make it possible for them to support themselves.

**Prognosis.**—Among the group in which the diagnosis of cerebral birth injury can be made at birth nearly 50 per cent die within a few days. The percentage of deaths, of course, depends on the care with which the children are observed, and is smaller if many mild cases are included. All but a few of the survivors make complete recoveries. The presence of blood in the spinal fluid without any accompanying clinical symptoms seems to have little or no serious significance. For example, Hines Roberts found blood in the spinal fluid of 60 children within three days of birth and in 26 of these children there were also clinical symptoms of birth injury. Twelve of the latter group died, while all of the others seemed quite normal at the time of writing, except for one child in whose case there was a suspicion of congenital syphilis. Fleming has followed 33 cases of birth injury



for over a year and only 5 are in any way defective. The prognosis must be guarded for some years, however, for small defects are often not evident in young children.

### SPINAL BIRTH INJURY

The injury that produces this kind of paralysis usually results from excessive force exerted during breech delivery, when there is difficulty in extracting the aftercoming head. The spinal column itself may be fractured or the cord may be torn as the result of the elongation of the vertebral column due to traction. The cauda equina is relatively fixed, and so is the cervical enlargement by its short horizontal roots. The cord with its enveloping membranes gives way to a greater or less extent at its weakest point, usually in the upper dorsal region. Hemorrhage takes place with extravasation of blood within the vertebral canal. The amount of hemorrhage varies within wide limits. In rare instances injury to the cord may result from efforts to deliver an arm, the roots being torn from the cord instead of the usual laceration of the brachial plexus. If the injury is high, or the hemorrhage large, death occurs immediately from pressure upon the medulla or from interference with the phrenic nuclei. If the child survives, resuscitation may be difficult; there may be convulsions and great weakness. In perhaps the majority of cases the first thing to attract attention is that the child moves no part of the body but the arms, fails to hold up the head or sit up at the usual time, though intelligence is not affected. Upon examination it is then found that in addition to paralysis of the abdominal muscles and the legs there is complete loss of sensation as high as the costal margins or higher.

The symptoms depend on the severity of the injury. If this is such as to cause complete paralysis, there is apt to be loss of all reflexes and muscular hypotonus below the level of the lesion. The skin is dry and ulcerates readily. Urine accumulates in the bladder and there is constant dribbling. This is the stage of spinal shock. If the patient's general condition is good and bed sores and urinary tract infections do not develop, a stage of reflex activity may appear. The tendon reflexes are easily obtained during this stage and there are spontaneous spasms involving the flexor muscles. A mass reflex is elicited in these cases by pinching the foot, and consists of a general flexion of all joints of the legs, violent sweating over the lower half of the body and usually discharge of urine. In this stage the bladder discharges some urine whenever it is distended to a certain degree. This is the so-called automatic bladder. Bed sores and trophic disturbances are not apt to occur while the reflexes are active. The legs are held flexed at all three joints, hence the term *paraplegia in flexion*. If the patient becomes ill or severe infection develops, the reflexes may disappear once more, and the patient revert to the condition of the first stage. When the lesion is only partial the legs are extended and spastic. The reflexes are increased and clonus and extensor responses present. Spinal shock is less pronounced. This is called *paraplegia in extension*. Children with spinal paralysis may live for years. They are intelligent and most of them can use their arms well, but they are unable to sit up owing to weakness of the back muscles and cannot move the lower extremities or control the bladder or rectum. Death is likely to occur from ascending infection of the urinary tract,



from pneumonia, or from some other intercurrent disease. Very rarely definite improvement takes place and a child may walk with assistance and be able to control vesical and rectal evacuations. Such an outcome is not to be expected.

Treatment in spinal paralysis can accomplish practically nothing. No operative procedure upon the cord is likely to be of any avail. Special attention to cleanliness should be observed and catheterization should be avoided. In the event that some muscular power in the legs returns, orthopedic treatment may assist in preventing contractures, perhaps even in standing or walking.

### FACIAL NERVE INJURY

The usual cause of congenital facial paralysis is the use of forceps, but this does not explain all cases. The etiology of those in which forceps have not been used is still somewhat obscure. In peripheral facial palsy the nerve is pressed upon, either near its exit from the stylomastoid foramen, or where it crosses the ramus of the jaw, at which point the parotid gland gives it but little protection in the newly born. If the lesion is in front of this point, any one of the terminal branches may be affected; most frequently it is the temporofacial branch. As only one blade of the forceps commonly touches the face in this region, the paralysis is, as a rule, unilateral.

Cases occasionally occur in which forceps have not been used. In these the pressure is believed to be produced by the promontory of the sacrum at the superior strait, or by the ischium at the inferior strait, as paralysis has followed when the head was long arrested at one of these points.

In repose, the only symptom noticed may be that the eye remains open upon the affected side, owing to paralysis of the orbicularis oculi. When the muscles are called into action, as in crying, the whole side of the face is seen to be affected. The paralyzed side is smooth, full, and often appears to be somewhat swollen. The mouth is drawn to the side not affected. In this paralysis, the tongue, of course, is not implicated. It is therefore rare that nursing is seriously interfered with.<sup>1</sup>

The paralysis is generally noticed on the first or second day of life, and does not increase in severity. Its course and termination depend upon the extent of the injury done to the nerve. Some idea of this may often be gained by the amount of injury to the soft parts, although this is not an infallible guide. In cases not due to the forceps, the paralysis is usually slight and disappears in a few days; the great majority of the forceps cases follow the same favorable course, the paralysis gradually disappearing without treatment in about two weeks. In more serious cases it may last for months, or it may be permanent. The reaction of degeneration is present in these severe cases. The recognition of facial paralysis offers little difficulty. The diagnosis of peripheral paralysis from palsies of central origin is a matter of some interest. Injury to the facial nucleus is usually accompanied by evidences of sixth nerve palsy. A supranuclear lesion spares the upper part of the face, while a peripheral lesion usually involves the whole nerve, the

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<sup>1</sup> In this connection it is to be remembered that the principal part in nursing is done by the tongue, and not by the lips.



upper branch as well as the lower; with a supranuclear lesion the electrical reactions are not affected.

Nothing should be done for the first ten days except to protect the eye and keep it clean. If improvement has begun by the end of this time, the probabilities are that the case will require no treatment. If no improvement has taken place by the end of the third or fourth week, electricity may be used, but probably has little value.

### BRACHIAL BIRTH PALSY

This condition, sometimes called "obstetrical paralysis" or "Duchenne-Erb paralysis," is unfortunately all too common. It is almost always unilateral, though occasionally both arms are involved. It may result from spontaneous delivery but is vastly more frequent following operative interference in difficult labor. In the majority of cases it is directly due to manipulation, though it may occur in the practice of the most skillful. Pressure from the application of forceps, while a possibility, is an infrequent cause. The injury may be produced by any manipulation that forcibly draws the head and neck away from the shoulder. This puts the brachial plexus upon the stretch. If the force is slight, only stretching of the nerves is caused; if more extreme, laceration of the nerves is produced. The supra-scapular nerve is by its position the one most exposed to injury and is the one that is first and most severely torn. The fifth cervical next is affected, then the sixth, the seventh and perhaps the eighth and the first dorsal. While the injury is almost always to the plexus alone, in some cases one or more roots in the cervical region may be torn from the cord. The amount of spontaneous improvement depends upon the extent of the lesion. When only overstretching has been produced, complete recovery may take place. The same may be true when the laceration of the nerves has been slight and the ends remain in apposition. When more extensive injury has taken place complete recovery cannot be expected. Hemorrhage occurs and there is laceration of the fascia as well as the nerves. The result is usually the production of a cicatricial mass that interrupts the continuity of the nerves and prevents their regeneration. The nerve impulses are thus blocked.

The paralysis in severe cases is noticed soon after birth, owing to the fact that the infant does not use the arm. In less severe cases it may escape detection for several weeks.

The most common form of peripheral paralysis is that known as the upper-arm type. The muscles paralyzed are the deltoid, biceps, brachialis anterior, supinator, and sometimes the supra- and infraspinatus. The arm hangs lifeless by the side; it is rotated inward, the forearm pronated, the palm looking outward (Fig. 134). The biceps reflex is lost. The forearm and hand are not affected, except in cases where the whole plexus has been lacerated. In severe cases there may be anesthesia of the outer surface of the arm. This is rarely marked, and in its slighter degrees is very difficult to determine. It is characteristic of this paralysis that the triceps is not affected, so that power to extend the forearm remains, although it cannot be flexed. A nodular mass in the region of the plexus may be felt. This is the result of the hemorrhage and the inflammatory reaction. Atrophy of the paralyzed muscles occurs after a few weeks, but the muscles



are so small and so covered with fat that it is rarely noticeable before the second year. It is most conspicuous in the deltoid. In all severe cases the reaction of degeneration is present. In some of the cases of long standing there occurs a shortening of the tendon of the subscapularis muscle, often associated with subluxation of the humerus. The paralysis may be complicated by fracture of the clavicle, the neck of the scapula, or the shaft of the humerus, or with epiphyseal separation of its head. Injury confined to one nerve is very uncommon. We have seen two cases in which there was temporary paralysis of only the muscles supplied by the radial nerve. The explanation of such cases is obscure.

In rare cases only the lower roots of the brachial plexus may be affected. This is the Klumpke type. The intrinsic muscles of the hand are paralyzed, and

the hand may be swollen and red. The sympathetic fibers in the first thoracic root may be injured, causing drooping of the eyelid and contraction of the pupil. In such cases the iris may fail to develop pigment as rapidly as the normal eye and remain blue for some months. Injuries to the phrenic nerve are reported but are very rare.

The prognosis depends upon the severity of the injury. Some cases recover spontaneously in a few months, improvement being observed within a few weeks, first in the biceps and last in the deltoid. If there is no improvement in two months recovery is most unlikely, though some improvement may continue to the end of the second year. The condition is a very serious one. There is usually some per-

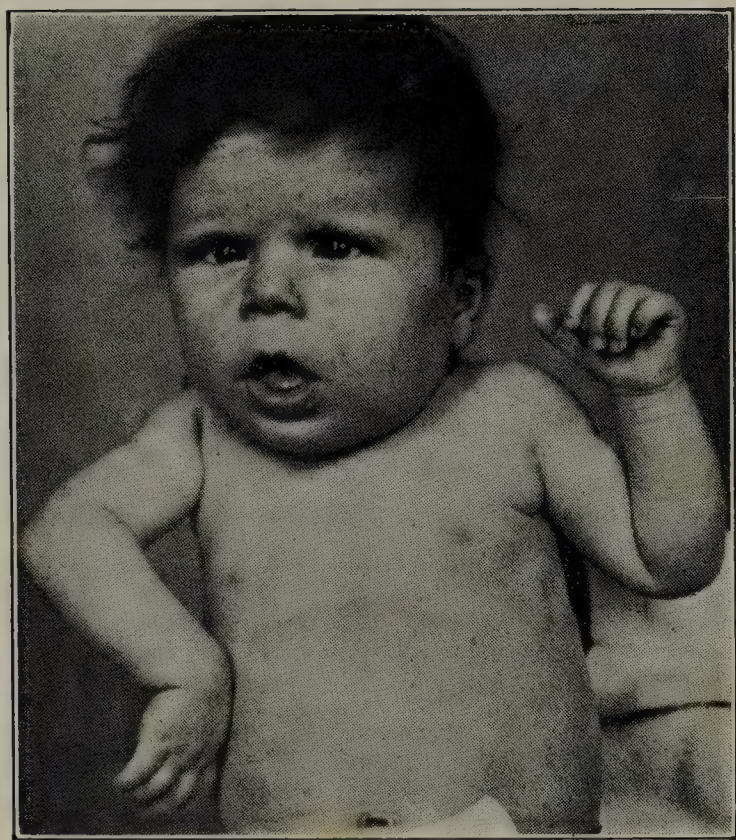


FIG. 134.—ERB'S PARALYSIS OF RIGHT ARM.

manent paralysis left and it may be so marked as to render the arm almost useless. Permanent paralysis is most frequently of the deltoid.

The electrical reactions are of some value in prognosis. If the muscles respond to faradism, rapid improvement can generally be predicted. If the reaction of degeneration is present, improvement will be slow and the paralysis is likely to be permanent.

The diagnosis is usually not difficult, since the great majority of cases are of the upper-arm type with classical symptoms. Peripheral palsy of the arm can hardly be confounded with that of cerebral origin. If the lesion is central the reflexes are increased, no atrophy is found, and the electrical reactions are normal. If the case does not come under observation until the child is a year old, it may be difficult, or without a good history it may be impossible to distinguish peripheral paralysis from that due to poliomyelitis. The particular group of muscles involved in Erb's paralysis is the chief diagnostic point.

In recent cases the disability resulting from the tenderness or pain of syphilitic epiphysitis may simulate paralysis, but there is lacking the characteristic position



of the arm, and a careful examination discloses the fact that the paralysis is only apparent. This may affect both sides. Fracture of the clavicle or epiphyseal separation of the head of the humerus may also be mistaken for paralysis. In cases of long standing, paralysis of the deltoid may simulate dislocation of the humerus. The reaction of degeneration differentiates paralysis from surgical injuries with similar deformities.

Fractures and dislocations may occur as complications and should be ruled out by examination and roentgenographic study.

**Treatment.**—As soon as the paralysis is discovered, the injured arm should be put at rest by means of an aeroplane splint. In the common type described by Erb the shoulder should be abducted and externally rotated, the elbow flexed to 90 degrees, the forearm supinated and the wrist and fingers extended. By this means the paralyzed muscles are relaxed and contracture of the uninjured muscles is prevented. In the other types of brachial plexus palsy, such as the rare Klumpke's type, the same rule should be followed, *i.e.*, the arm should be placed in such a position that the paralyzed muscles are relaxed and their antagonists are stretched. At the end of two or three weeks, gentle massage may be employed twice a day. When power begins to return, the splint may be removed for a short time every day and the child encouraged to move the arm. If, at the end of six months or a year, no substantial improvement has occurred, or even if considerable paralysis still remains, operation should be considered. This consists in dissecting out and suturing the roots ruptured by the injury. The operation is very delicate and requires great skill and patience. An unskillful surgeon may do more harm than good. The field for this operation is a very small one, for in mild cases recovery will occur with conservative treatment, and in severe cases the roots are often avulsed from the spinal cord and, hence, cannot be sutured.

In old cases which have been neglected and in which there are contractures and sometimes bony deformities, orthopedic operations offer some prospect of improvement by the removal of mechanical causes for limitation of movement.

## CEREBRAL INJURIES NOT ASSOCIATED WITH BIRTH

Head injuries in the acute stages are problems for the neurosurgeon and consequently will not be discussed here. The nervous and mental sequelae, however, may well be considered, for they frequently present very difficult problems in diagnosis and treatment.

*Depressed fractures of the vertex* and cortical hemorrhages cause monoplegia, hemiplegia, hemianopia and aphasia depending on the cortical area involved. The hemiplegic cases are indistinguishable from other infantile hemiplegias, with contractures, defective development of the affected limbs and often focal epilepsy. The aphasias rarely persist, although speech may be childish for some time. *Fractures of the base* may leave residua such as optic atrophy, deafness, and ophthalmoplegia due to involvement of the cranial nerves. A less common result is subdural hematoma, which may cause no symptoms for some weeks or even months after the injury, so that their relationship to the injury may not be suspected. The symptoms include headache, vomiting, drowsiness or mental confusion, and stupor. Even in unilateral hematomata focal signs are inconspicuous or



absent. Internal squints are common and nystagmus is sometimes seen. The head may enlarge and the sutures separate. The retinal veins are usually engorged and tortuous and retinal hemorrhages, often of large size, are frequent. True papilledema is described. Puncture of the fontanel reveals yellow fluid even when the spinal fluid is quite clear. Treatment is by removal of the fluid by repeated fontanel puncture or if necessary by craniotomy and removal of the hematoma.

Even more interesting are the mental disturbances that follow *cerebral concussion*. The picture is that of the so-called traumatic constitution. In such cases the change in behavior is most striking. The symptoms are somewhat modified by the patient's previous personality but there is, nevertheless, a fairly characteristic syndrome, including emotional instability, explosive outbursts, temper tantrums, confusion states and fugues, irritability, lack of attention, mental fatigue and vasomotor instability. Epilepsy is not infrequent. Intelligence is not greatly diminished in most cases. Some of these children require special training and some become problems of the juvenile court. No doubt these disorders depend on the multiple petechial hemorrhages which are found in the brains of patients who die soon after severe head injuries. The treatment is prolonged rest, quiet, systematic routine and bromides or other sedatives. The prognosis is unfavorable in most cases.

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## CHAPTER CXIV

### INFECTIONS OF THE NERVOUS SYSTEM

#### EPIDEMIC ENCEPHALITIS

Attention was first directed to epidemic encephalitis in 1917 by von Economo of Vienna, although it had doubtless existed long before that time. Indeed, descriptions of some mysterious malady which may have been epidemic encephalitis are to be found in medical literature as early as the sixteenth century.

**Etiology.**—Several different viruses have been held responsible, but none of these has been generally accepted as the cause of the disease. Much stress was at first placed on a possible relationship with influenza, for the first cases in this country occurred in the wake of the 1918 epidemic of influenza. In Vienna, however, encephalitis preceded the influenza and it is now generally accepted that they are entirely separate diseases. It has also been claimed that Australian X disease and epidemic hiccup are related to epidemic encephalitis, but the relationship is not very clear in either case. Much experimental work has been done and several viruses have been offered as the causative agent, among others the virus of herpes simplex. None of these claims has yet been established and we must admit that we do not know the cause of epidemic encephalitis and cannot even feel sure that it has been transmitted to experimental animals.

**Pathology.**—The lesions are confined to the central nervous system. On external examination little is to be seen except for congestion of the cortical veins and sometimes a few small meningeal hemorrhages. On section minute petechiae may be visible in the gray matter of the midbrain. The microscopic lesions are most severe in the brain stem and involve especially the nuclear masses such as the nuclei of the cranial nerves, the substantia nigra, globus pallidus and subthalamic nuclei. The medulla and pons are also gravely involved, but perhaps not as frequently as the midbrain. The white matter is rarely affected. Only a slight meningeal reaction is found except in unusual cases. It is also rare to have extensive changes in the cortex. The spinal cord may be involved to a limited extent, and the spinal roots and posterior root ganglia may be infiltrated.

In acute cases vascular engorgement is conspicuous and minute hemorrhages are often found. Small vascular thrombi are seen and even small softenings. The most characteristic feature is the infiltration of the perivascular sheath of small veins and arteries with lymphocytes, plasma cells and even an occasional polymorphonuclear leukocyte. Small round cells resembling lymphocytes are also seen scattered throughout the affected areas in the gray matter. There is usually a moderate chromatolysis of all the nerve cells in the region of the lesion, but complete necrosis such as is seen in poliomyelitis is never found. The glial reaction is moderate.

In chronic cases of long standing the picture is very different. Perivascular



cellular accumulations are few and confined to small foci. The degeneration of the nerve cells is now most conspicuous. In Parkinson's syndrome it is usual to find great reduction in the cells of the substantia nigra and evidences of disintegration in others. The glial nuclei are increased. The vessel walls are often thickened and may contain calcium.

**Symptoms.**—The clinical picture is so diversified and so many different types are described that no brief account can do full justice to the facts. The situation has also been complicated by the tendency to include almost any unusual nervous condition in this group, and if one should take the literature on this subject at its face value no clear idea of the disease could be attained.

The onset may be sudden, or so insidious that it is impossible to say when the illness began. In the early epidemics of 1917 and 1919 the sudden onset with fever was the usual one. At present the gradual onset is more frequent. The first cases began with headache, fever, vertigo, diplopia, convulsions, and with progressive somnolence. There were almost invariably ptosis of the eyelids and various oculomotor palsies of nuclear type. The pupils were dilated, contracted or unequal. The accommodation reaction was usually absent or reduced, and the reaction to light was sometimes also abolished. The face was relaxed, and slight weakness of one or both sides was often present. The somnolence was peculiar in that the patient was generally quite clear when aroused but would at once relapse into sleep when again left to himself. Fever was rarely very high, but might reach 104° F. It seldom continued into the second week. The leukocytes ranged between 10,000 and 15,000. Irregular tremors of the hands were common. Rhythmical clonic movements of the abdominal, facial and other muscle groups were very characteristic and present in a large percentage of cases. These occurred at a rate of from 40 to 60 per minute, often in a simple ratio to the respiratory rate, and did not stop during sleep. The diaphragm was sometimes involved, causing hiccup. In many cases there were severe pains following the course of the spinal nerves. Trismus was an occasional finding. Bulbar disturbances were infrequent and sensory loss rare. Meningeal symptoms, such as cervical rigidity and Kernig's sign, were not usually prominent. In some cases there was excitement in place of somnolence. These patients were apt to be delirious and often showed choreic movements. Papilledema or optic neuritis sometimes occurred, but in most of the cases reported to show this feature a brain tumor was eventually found. In a few instances the onset was apoplectic with hemiplegia or hemianopia, but there is still some question about the true nature of such cases; in epidemic encephalitis actual paralysis is uncommon. The tendon reflexes were not consistently altered. Bilateral or unilateral extensor response on plantar stimulation was not unusual in the early stages of the disease.

After several weeks or months a definite improvement usually began. The somnolence, twitchings and other symptoms disappeared and in many cases the patient seemed quite well. This remission might be partial or complete, long or brief. Remissions of four years were known. In many cases, however, no appreciable improvement in the patient's condition occurred and the symptoms merged with those of the late stage.

At present the acute symptoms outlined above are rarely seen and we are accus-



tomed to see the disease make its appearance by the gradual development of the late symptoms. These are so varied and occur in such numerous combinations that it is impossible to give all the possible types. In the following description, therefore, each symptom will be discussed separately and it must be understood that several symptom groups may be present in a single patient. Epidemic encephalitis is in most cases progressive, and it is preferable not to term the late symptoms "postencephalitic" phenomena, but to regard them as representative of the chronic, but still active, stage of the disease.

One of the most serious late manifestations of epidemic encephalitis is *Parkinson's syndrome*, which is rare in infants but common in older children. This picture includes a special type of muscular rigidity, a rhythmic tremor of rest, and striking alterations of posture and expression. The face is rigid and mask-like and the spontaneous play of expression is diminished or lost, although laughing may still cause the usual facial movements, and there is no real paralysis. The eyes have a staring expression. Fixed smiles are sometimes seen and the mouth may be held open. All movements of the body and extremities are slow and stiff. The limbs, jaws, or head may show a coarse rhythmic tremor which tends to resemble that seen in paralysis agitans, being usually inhibited by movement. It is frequently atypical, however. On passive movement it is found that there is a marked increase in muscle tone very different in its characteristics from that due to pyramidal lesions. When the limb is bent the muscle stretches in a jerky fashion, giving the feeling that there is a cog in the joint. This is called the *cog-wheel phenomenon*. The tendon reflexes are not consistently altered and the plantar reflex is normal. There is often some slowness and jerkiness of the ocular movements, as well as weakness of convergence and accommodation. Speech is slow and voice low-pitched. There is very little inflection or variation in pitch of the voice, which is well described as monotonous. The gait is slow and shuffling. The arms do not swing. There may be a tendency to run forward (propulsion) or backwards (retropulsion). Strangely enough some children who cannot walk, can run or even dance almost as actively as in health. Although it is usually taught that there is no actual paralysis in this syndrome, our experience has been that these patients ultimately become entirely helpless and bed-ridden.

Many other disturbances of motility are described. The myoclonus and choreiform movements may continue into the late stages, although this is unusual. Tremors have been mentioned in connection with Parkinson's syndrome, but there are also other less typical tremors, some of which resemble the "intention" tremor. Slow rhythmic movements of large amplitude are also known. These are called bradykinesias. Torsion spasm or dystonia has been described.

The pupils are frequently unequal and characteristically do not contract during accommodation and convergence. The light reaction is often sluggish and may be absent, but typical Argyll Robertson pupils are very rare. There is frequently slight ptosis of the lids and convergence is weak or lost in many cases. Nuclear ophthalmoplegias, incomplete in most instances, are not uncommon. Lesions of the other cranial nerves are infrequent.

Among the most strange and characteristic symptoms of encephalitis are the forced ocular movements, or oculogyric crises. These consist of involuntary con-



jugate deviations of the eyes, usually upwards but also in other planes. They may stay in this position for hours despite the patient's efforts to release them. There are often emotional and trance-like states associated.

Respiratory disturbances are also very characteristic. The commonest type is represented by paroxysms of rapid breathing, but there are also apneic pauses, Cheyne-Stokes respiration, alternation of deep and shallow breathing, and breath-holding spells. Tetany sometimes results from the excessive elimination of carbon dioxide by overventilation in such conditions. Cyanosis may follow due to apnea. There are also attacks of coughing, yawning, spitting and similar compulsive episodes.

Elaborate movements, usually classed as psychogenic tics, sometimes follow encephalitis in children. These are sometimes associated with respiratory disturbances or may be isolated. Several cases have been seen in this clinic which resembled saluting. In one case the "salute" was followed by hyperpnea, foaming at the mouth and striking the lips with the hand. There was usually excitement and anger at the same time.

Sleep disturbances are frequent. The tendency to lethargy may persist into the late stages in a few cases. Less common but just as typical is persistent insomnia. The alteration of sleep rhythm is especially frequent in children. As night comes on these patients become more and more excited until they are in constant activity, singing, laughing and shouting. This will continue until the early hours of the morning, when the child will grow drowsy and fall into a deep sleep which may continue until the next night.

Metabolic changes are of great interest, and are attributed to lesions in the infundibulum. Obesity of pathological degree is not uncommon and this is often associated with genital atrophy. Polyuria and polydipsia are often seen. Precocious sexual development is described. States resembling hyperthyroidism have been observed. Extreme emaciation is sometimes seen, especially in connection with Parkinson's syndrome.

Mental abnormalities follow encephalitis very frequently in children, much oftener than in adults. In older children intellectual development is not arrested to any considerable extent, but emotional reactions and personality suffer a great change. The result is impulsive and often antisocial conduct, sometimes leading to the necessity of commitment to an institution. These children will steal, lie, commit acts of violence, arson and sexual offenses as the opportunity offers itself. Their misdeeds are not usually planned in advance but arise from the inability to resist their impulses. In infants affected by encephalitis there is often impairment of all mental functions, causing idiocy of various grades.

Epileptic seizures, both focal and general, are rare but are described. Wimmer has reported tonic spasms due, he thinks, to striate lesions.

*Spinal Fluid.*—The spinal fluid during the acute stage of encephalitis may be normal. Commonly, however, it shows an increase in the number of cells, usually 20 to 60 per c.mm. The cells are of the mononuclear type, and rarely exceed 200 per c.mm. Associated with the increase in cells there is a moderate increase in the globulin content. The sugar content is normal or somewhat increased; the chlorides are not affected. After a week or ten days the spinal fluid is normal.



**Prognosis.**—The immediate mortality is between 20 and 40 per cent, varying with the age of the patient. The ultimate mortality must be high, for this is a progressive disease, but exact figures are lacking. Provided the patient survives the acute stage the outlook is still not very encouraging. Not more than 25 per cent of all patients are well after three years, and, if we allow for a large percentage of error in the diagnosis, it seems likely that few patients make complete and permanent recoveries. In fact, complete and lasting recovery may well throw some doubt on the accuracy of the diagnosis.

**Diagnosis.**—The diagnosis is easy if the typical symptoms are present, but difficult if they are not. It is based on the characteristic clinical features, and hence the atypical cases such as the spinal, meningeal, polyneuritic, etc., cannot be diagnosed unless they are accompanied by other typical features or are followed by the usual late symptoms. There has been an unfortunate tendency to include many syndromes in this group on insufficient evidence. There are many cerebral conditions in childhood about which we are still very ignorant, and it does not seem wise to make the diagnosis of epidemic encephalitis by exclusion of familiar entities. In the early stages, encephalitis must be distinguished from tuberculous meningitis, syphilis, poliomyelitis and the disseminated encephalomyelitis following acute infections. Tuberculous meningitis may be recognized by the presence of tubercle bacilli in the spinal fluid, film formation, high globulin content and steadily falling chlorides and sugar. The meningeal symptoms are usually more pronounced than in encephalitis and there may be tubercles in the choroid. The course, moreover, is steadily progressive in most cases. Poliomyelitis is distinguished by the predominantly spinal localization and the flaccid type of paralysis; syphilis by the Wassermann reaction and the associated stigmata of congenital syphilis, and postinfectious encephalomyelitis by the history of a preceding infection, the prompt improvement and the absence of any tendency to development of late sequelae. In the later stages the diagnosis of encephalitis may be very difficult, for the symptoms may simulate very closely those of cerebral defects and degenerations. In the cases in which the characteristic symptoms are absent, and in which no history of an acute illness can be obtained, the diagnosis cannot be made with confidence.

**Treatment.**—During the acute stage the patient should be kept in bed and given proper nursing care as in other acute infections. No specific remedies are known which affect the course of the disease. The use of convalescent serum has some theoretical justification but has not proved of value. If there is excitement or choreiform movements, sedatives should be given. Luminal is very useful.

In the late stages of the disease every effort should be made to keep the patient's resistance at the highest possible level. Especially in the parkinsonian states the child should be kept out-of-doors most of the day and should take as much exercise as strength permits. If possible the child should be taken south in winter and north in summer, so that outdoor life will not be limited by inclement weather. The muscular rigidity may be favorably influenced by tincture of stramonium or hyoscine hydrobromide, but the tremor does not respond well to these drugs. Very large doses are necessary to obtain successful results. Hyoscine may be given in doses of 1/200 grain three times a day after meals and gradually in-



creased over a period of several months to at least twice that dose. Tincture of stramonium is given in doses of 15 drops three times a day after meals, to 60 or 70 drops. Massage has little if any value.

Mental symptoms require special training. This can be carried out most successfully in schools for delinquent children or other institutions. Impersonal discipline and firm but sympathetic handling are required. This is usually impossible at home. Occupational therapy is sometimes of value. In speech disturbances, special training may be tried but is usually unsuccessful.

## ENCEPHALOMYELITIS FOLLOWING ACUTE INFECTIONS

All acute infectious diseases are sometimes complicated by nervous symptoms which indicate involvement of the brain, spinal cord, or meninges. At present there is no general agreement about the etiology of such cases. Some authors maintain that there is invasion of the nervous system by the virus of the disease or by its toxins; others believe in a hypothetical neurotropic virus which is activated by the disease or enters as a secondary invader when the patient's resistance is lowered. It must be said that no such neurotropic virus has ever been demonstrated. The symptoms associated with the various diseases of childhood present certain differences; some of the commonest will be outlined briefly below.

**Measles.**—Nervous symptoms occur in about one-half of one per cent of all cases of measles. The onset is usually on the fourth to the sixth day, when the fever has fallen and the rash begun to fade, but it may also occur at the height of the fever or in rare instances even during the prodromal period. The nervous symptoms are initiated by drowsiness and convulsions, followed by stupor and accompanied by a sharp secondary rise of temperature. Muscular rigidity and twitching are typical at this stage. There may be mild meningeal symptoms. From this stupor the child may recover promptly without residual symptoms, or the stupor may be prolonged and returning consciousness may reveal a great variety of nervous symptoms. Spastic paralyses, ataxias, tremor, choreiform or athetoid movements, myoclonus, bulbar disturbances and aphasia are all described. Cerebellar ataxias are not uncommon and spinal lesions constitute a large group. Mental disturbances during convalescence are sometimes observed.

The spinal fluid shows a moderate increase in lymphocytes and in very rare cases the count may reach 200. A small percentage of polymorphonuclear leukocytes may be present. The protein is moderately increased.

The prognosis for life is good and the mortality is only about 10 per cent. Unfortunately many of those who survive show permanent nervous symptoms, chiefly spastic paraparesis, hemiparesis, cerebellar ataxia and mental defects. There are no late sequelae such as are seen in epidemic encephalitis.

In the fatal cases small discrete lesions are found scattered throughout the central nervous system. Histologically the process is a perivascular myelin destruction with accumulation of fat-laden phagocytes in and about the lesions. In a few cases numerous lymphocytes have been found in the perivascular spaces but this feature is usually not conspicuous. The veins are usually congested and a few red cells are sometimes found in the perivascular spaces. There is very little injury to the axis cylinders and nerve cells, and large thromboses and softenings are not



seen. The meningeal reaction is very moderate. In general the white matter is more severely affected than the gray matter.

**Vaccinia.**—Disseminated encephalomyelitis of a type almost identical with that described above may occur after vaccination against smallpox. The symptoms make their appearance about the tenth day, varying between extremes of four and thirty days. The onset is usually marked by headache, vomiting, fever and drowsiness. Cranial nerve symptoms are not prominent, but the pupils may be unequal and ocular palsies are described. The legs are usually paralyzed and sphincter control is lost. Stiffness of the neck and Kernig's sign are sometimes found but are not prominent in most instances. Trismus is sometimes present. The mortality is high, usually above 50 per cent, but those who survive generally make complete recoveries. The changes in the spinal fluid are slight and similar to those found in measles encephalitis. The pathological picture is that of perivascular demyelination with proliferation of the microglia and phagocytosis of the broken-down myelin; it is almost identical with that of measles encephalitis.

**Pertussis.**—This is also sometimes a cause of profound nervous disturbances. These usually are initiated by convulsions, which may cease promptly without sequelae or may be followed by signs of cerebral damage such as hemiplegia, tremors, visual disturbances or mental change. In some cases the convulsions are followed by drowsiness deepening into coma. General muscular rigidity slowly develops and in several weeks all cerebral function seems to be abolished except for that of the vital centers of the medulla, so that the child presents the appearance of decerebration. There may be an increase of lymphocytes in the spinal fluid. Death may be long deferred and is usually due to secondary infections. On post-mortem examination there is found extensive atrophy of the cerebral cortex, due to degeneration of the neurons. No vascular or inflammatory lesions are found. The process is diffuse but seems to involve chiefly the cerebral and cerebellar cortex. In severe cases the cortex is reduced to a mere sponge composed of glial fibers completely devoid of nerve cells. Meningeal hemorrhages and even small cerebral hemorrhages are sometimes found. These are said to be more common in the hemiplegic types.

**Mumps.**—Meningitis is frequently described in association with mumps. This complication may develop before the parotitis has appeared or at the height of the disease, but usually occurs later, sometimes in connection with orchitis. The usual picture includes fever, vomiting, delirium, opisthotonos, cervical rigidity and Kernig's sign. There is always an increase in lymphocytes in the spinal fluid, and counts up to one thousand per cubic millimeter are recorded. Cerebral symptoms are also described, such as facial palsy of central type, ophthalmoplegias, hemiplegia and aphasia; it is probable that this is really a meningo-encephalitis, although the meningeal reaction predominates. The mortality is very low and complete recovery is the rule. It is interesting that a marked pleocytosis may be found in the spinal fluid of patients who have no clinical signs of meningitis, and that meningitis has been known to occur without parotitis at the same time that other children in the family have had typical mumps. Multiple neuritis is a rare sequel of mumps and develops about two weeks after the onset. A large number of cases of unilateral deafness are also attributed to this disease. This develops suddenly with



vomiting and vertigo and without evidence of otitis. It is frequently permanent. Complete pathological studies of mumps meningitis are still lacking.

**Other Infectious Diseases.**—Variola is sometimes complicated by an encephalomyelitis similar to that associated with vaccinia. Turnbull and McIntosh have shown the two lesions to be almost identical. Disseminated encephalomyelitis and myelitis have been observed in a very few cases of varicella, but no pathological studies have been made. Antirabies inoculation was formerly sometimes followed by encephalomyelitis before the carbolized virus was introduced; at autopsy disseminated perivascular demyelination was the most conspicuous finding. Rabies due to street virus, however, has been shown to be a form of encephalitis involving chiefly the brain stem and very similar in its histological characteristics to epidemic encephalitis.

Almost all severe infections, such as scarlet fever, typhoid fever, bronchopneumonia and septicemia as well as nephritis and various nonbacterial intoxications, may cause a hemorrhagic encephalitis. The clinical picture differs in no way from that observed in the encephalitis following measles. A lymphocytic reaction is usually present in the spinal fluid. This condition has been recently studied by Alpers, who showed that the lesions always center around small blood vessels. Surrounding the vessel is an area of necrosis, about which is a zone of glial cells identified with the oligodendroglia; just outside the glial cells is a zone infiltrated with red blood cells which have probably seeped in from the surrounding capillaries, thus giving rise to the descriptive term, "ring hemorrhages." This condition is not characteristic of any disease and may be regarded as perivascular necrosis due to any blood-borne poison.

## ACUTE DISSEMINATED ENCEPHALOMYELITIS OF UNKNOWN ETIOLOGY

In the last few years cases have been observed both sporadically and in small epidemics which are very similar both clinically and pathologically to the encephalomyelitis associated with measles and vaccinia, and differ quite markedly from epidemic encephalitis. Some neurologists believe that this disease is closely related to the so-called *acute multiple sclerosis* and the equally vague *neuromyelitis optica*; others believe that it is a disease *sui generis*. The outlines of this group are still very indistinct and further study may reveal that we are dealing with more than one disease.

## HEMIPLEGIA OF UNKNOWN ETIOLOGY

This clinical picture was described by Strümpell in 1885. The onset is usually with high fever and vomiting and with convulsions which are severe and frequently repeated. It is uncommon for paralysis to be the first and only striking symptom. The convulsions are often general, affecting one side of the body more than the other, perhaps exclusively so. They are followed by stupor, which may become deep coma. The temperature is from 101° to 103° F., sometimes higher, and continues three, four, or more days when it usually falls by lysis. The fever sometimes follows, sometimes precedes the convulsions. There is usually no increase of cells or of globulin in the cerebrospinal fluid. Though the children are very ill and



seem likely to die, they seldom do so in this stage and it is for this reason that our knowledge regarding the pathology of the condition is so meager and unsatisfactory. At the end of a few hours or days after the onset it is noticed that there is paralysis of the hemiplegic type. The leg, arm, and face are implicated, and usually the tongue, which is deflected to the side opposite the hemiplegia. There is often a deviation of the eyes so that they look toward the paralyzed side. Hemianopia is uncommon. We have seen it but once. The paralysis, which at first may be complete, tends to improve rapidly so that after a variable period of from one to several weeks the child begins to use the extremities, first the leg and then the arm as in adult hemiplegia. Recovery of the face is usually complete. That in the leg is sometimes complete, but some permanent paralysis usually remains and the arm practically never escapes. There remain paralysis, spasticity, and some contracture. The child walks with a limp. Contractures of the leg lead to various forms of talipes, usually equinus, from shortening of the Achilles tendon. The arm is flexed at the elbow and wrist and pressed close to the side.

At first, especially when the lesion is on the left side, speech may be temporarily affected. Disturbances of sensation are rare and transitory. In old paralyzed cases the limbs are atrophied. The superficial reflexes are unaffected, the deep reflexes exaggerated. There may be ankle clonus. As late symptoms may be found tremor and athetosis of the affected side.

The mental condition of these children is usually normal for a time at least, in striking contrast to the cases of congenital diplegia. The most distressing aspect of the disease is the great tendency to the development of epilepsy with mental deterioration. The epilepsy may be of the localized jacksonian type or there may be general convulsions or repeated attacks of *petit mal*. When the epileptic attacks are frequently repeated some degree of mental impairment usually ensues and this may progress to complete idiocy. On the other hand, in some of these patients nearly complete recovery takes place. The residual paralysis is so slight as to be easily overlooked except on careful examination, and no symptoms of epilepsy may appear even after many years. Unfortunately such cases are the exception.

Strümpell believed that the etiology was the same as that of acute anterior poliomyelitis, and it has been generally assumed that it is an encephalitis of some type. For this view there is no convincing proof. The few autopsies that have been performed in the acute stage have revealed only thrombosis or hemorrhage of the cerebral vessels. These observations are, however, so few that we cannot assume that they are characteristic of this group.

### ACUTE CEREBELLAR ATAXIA

This syndrome may follow almost any one of the exanthemata of childhood or may occur without discoverable antecedent. The onset is with fever, and sometimes delirium or unconsciousness; convulsions are unusual. These acute symptoms clear up in a few days, but when the child becomes active again it is found that there is more or less ataxia of cerebellar type. The symptoms may include intention tremor, cerebellar gait, speech disturbances, nystagmus and hypotonus. In many cases the symptoms indicate that the lesions are not entirely confined to the cerebellar apparatus, for increased tendon reflexes, ankle clonus and even extensor



plantar responses may be found. In general there is a tendency towards improvement and in mild cases recovery may occur. In severe cases the incoördination persists for many years and may be permanent.

Very little is known about the pathological anatomy. In the cases which follow measles the lesions are, no doubt, identical with those found in the more diffuse measles encephalomyelitis but are so placed as to cause chiefly cerebellar ataxia. In the cases without known etiology the real nature of the lesions is unknown.

### MYELITIS

Myelitis is a rare disease in children, with the exception of acute anterior poliomyelitis. We have mentioned above that form which occurs as a complication of acute infectious diseases. It may also occur in septicemia and pyemia. In rare cases no history of any preceding disease can be obtained, but nevertheless it is probable that such cases are also of infectious origin. Myelitis usually occurs in children over ten years of age. In situation, it may be transverse, diffuse, or disseminated; the process may be acute, subacute, or chronic. The lesions and the symptoms are essentially the same as when the disease occurs in the adult.

Myelitis usually comes on rather gradually, with only local symptoms; but the onset may be quite acute, with various general symptoms—fever, pain, prostration, and localized or general convulsions. The local symptoms vary with the seat and the extent of the disease.

In transverse myelitis loss of power and anesthesia are present below the level of the lesion; either of these may be partial or complete. At the level of the lesion there is a zone of hyperesthesia and “girdle pains.” All the reflexes below the seat of the lesion are exaggerated. Those at the level of the lesion are lost. There may be loss of control of the sphincters, bed sores, degenerative changes in the paralyzed muscles, contractures, and vasomotor disturbances. The paralyzed muscles may be rigid or flaccid, according to the seat of the lesion.

If the etiology is unknown and no specific therapy is possible, treatment is restricted to keeping the patient clean and changing the position frequently so as to avoid bed sores, cystitis and pneumonia. After convalescence massage and exercises are indicated, and later orthopedic measures may be of value in preventing deformities and correcting muscle balance.

### PACHYMENINGITIS

Pachymeningitis, or inflammation of the dura mater, occurs both as an acute and a chronic disease.

**Acute Pachymeningitis.**—This is very rare in children. Only pachymeningitis externa is generally included under this term, as acute pachymeningitis interna does not occur alone, but usually with inflammation of the pia mater (leptomeningitis). Acute pachymeningitis externa may be associated with disease or injury of the bones of the skull such as a depressed fracture, but is most frequently seen in connection with middle-ear disease. It generally begins as a localized process, but the inflammation may extend to the inner layer of the dura, and to the pia mater; or it may remain circumscribed, and terminate in the formation of an abscess between the dura mater and the bone.



The symptoms of acute pachymeningitis are distinctive only when the process is localized. They are then usually associated with middle-ear disease, and are indistinguishable from those of cerebral abscess. The treatment is surgical.

**Chronic Pachymeningitis.**—This, in children, almost invariably affects the inner layer of the dura mater (pachymeningitis interna); it is also known as pseudomembranous and as hemorrhagic pachymeningitis or hematoma of the dura mater. Its causes are for the most part unknown. Trauma at birth or subsequently and acute infections may play some part. It is a rather rare condition, and may be discovered only at autopsy in children who have died of other diseases. Usually, however, the condition produces definite symptoms.

The essential pathological changes consist in the formation of a thin, translucent membrane containing many blood vessels. This forms on the falx, the upper surface of the tentorium, the inner surface of the dura covering the frontal and parietal bones, and in the anterior and middle cranial fossae. It is seldom if ever found in the posterior fossa. The membrane is pinkish and usually discolored by small hemorrhages. It is composed of lamellae between which a serous fluid collects. The membrane may be only a delicate film which can be scraped off, or the cyst wall may be as thick as blotting paper. The accumulation of fluid produces a rupture of blood vessels that connect the lamellae, and in this way hemorrhages occur. The blood does not coagulate within the cysts and may remain for months. Eventually the fluid is absorbed, leaving a thickened dura with perhaps areas of pigmentation.

*Symptoms.*—These depend upon the intracranial collection of fluid and not upon an inflammatory process. The onset may be gradual or sudden. The child may be restless, out of sorts and pale for some time before it is noticed that his head is increasing in size; or the first symptoms may be vomiting, convulsions and pain. This last shows itself by the child's crying and grasping his head.

The head increases in size regularly or intermittently. The increase in the circumference may amount to as much as 5 centimeters or even more. The shape is much like that of the hydrocephalic cranium; the sutures may be separated and the veins prominent. During the acute stage the neck is somewhat stiff. There may be nystagmus and internal or external strabismus. The diagnosis is confirmed by an examination of the fluid obtained by puncture through the fontanel, and by examination of the eyegrounds. The fluid removed by puncture from just beneath the dura is intensely bloody. Fibrin forms on standing. Usually the red cells can be centrifuged off, leaving a clear yellow fluid containing no free hemoglobin. This bloody fluid is obtained from one of the cysts, for the cerebrospinal fluid obtained by puncture of the ventricle is often quite colorless. Retinal hemorrhages can be observed in nearly half of the cases. They are present in one or both eyes, and are usually subhyaloid. The hemorrhagic areas may be small or quite large. Other changes in the eyegrounds are optic neuritis and atrophy, rarely papilledema. The temperature is normal or slightly elevated. If death occurs there is apt to be an antemortem rise. The course of the disease varies. It may last for a few weeks and terminate in recovery, or there may be exacerbations and remissions throughout several months. The head may diminish and again increase in size. The absorption of fluid may be so rapid as to leave for some time a deep depression of the fonta-



nel. Perhaps the majority of patients recover, but death may take place from intercurrent infections, inanition, or from a particularly virulent form of the disease in which the accumulation of fluid takes place continuously and the course of which is marked by repeated convulsions alternating with stupor. Even when apparent recovery takes place there may remain mental retardation, which is permanent in a certain proportion of the cases.

*Treatment.*—The treatment of hemorrhagic pachymeningitis is symptomatic. The indications are: to relieve cerebral congestion by applying ice to the head, to allay irritative symptoms by the use of sedatives and to keep the patient perfectly quiet. If there is great intracranial pressure this may be relieved by lumbar puncture, or by puncturing the dura through the fontanel, or, if this is closed, after trephining. Removal of the hematoma by craniotomy may be necessary.

### THROMBOSIS OF THE SINUSES OF THE DURA MATER

This is not of very frequent occurrence. Among 58,000 admissions to the Harriet Lane Home, it occurred but 23 times. It is customary to distinguish between inflammatory or *septic thrombosis* and a so-called *marantic* or *cachectic* type. In the former obvious inflammatory changes are found in the thrombus; in the latter, evidences of inflammation are inconspicuous; infection in some part of the body is always present, however, and even here it is probably of etiological significance. The two types will therefore be considered together.

Sinus thrombosis is most frequently seen in children with acute or chronic otitis media, or mastoiditis. It may accompany meningitis, osteomyelitis of the cranial bones, or any septic process in the nasopharynx or accessory sinuses. In the orbit, the source may be malignant disease. In exceptional instances, a local cause is not apparent; the infection may be conveyed by the blood stream from a source which escapes notice.

The seat of thrombosis will depend upon the original disease. The lateral and sigmoid sinuses are usually first involved with ear or mastoid infections; the superior longitudinal sinus may be first affected if the process originates from the table of the skull or the meninges; lesions of the nasopharynx, the orbit or the base of the brain may extend to the cavernous sinus.

The thrombus may extend in either direction from its point of origin. It may exhibit few evidences of inflammation or there may be purulent softening of the clot with the development of general pyemia and secondary abscesses in the brain and elsewhere. It may lead to general or localized meningitis.

The symptoms of thrombosis may be entirely wanting. When occurring in the course of meningitis it seldom adds new symptoms to the original disease. In most cases, however, marked septic symptoms are seen. There are often recurring chills with very high and widely fluctuating temperature. There is headache and often localized tenderness of the scalp; meningeal symptoms are likely to be present. If metastasis occurs, there may be evidences of abscess in the brain or other organs; there may be suppuration of the jugular vein. Leukocytosis is usually high and a positive blood culture is frequently obtained.

Local symptoms differ according to the sinus affected; if the seat is the superior longitudinal sinus, evidences of cortical irritation are likely to be present, resulting



from a localized meningitis; there may be cyanosis of the face, dilatation of the frontal and temporal veins, and sometimes epistaxis. With involvement of the lateral sinus, the process may extend to the jugular vein, which may be felt in the neck as a hard cord; there may be dilatation of the veins of the mastoid region or local edema. On compression of the jugular vein on the unaffected side, the veins of the scalp or the retinal veins may become dilated. When the cavernous sinus is affected there may be exophthalmos of the affected eye, edema of the lid or chemosis; the retinal veins may be dilated. The process may affect first one eye and then the other.

Lumbar puncture may be of some assistance in diagnosis when the condition is not complicated by meningitis. The fluid may be under pressure, with a normal or slightly increased cell count and a moderate increase of globulin; organisms are not found. At times the fluid may be blood-tinged or xanthochromic. The diagnosis of lateral sinus occlusion may be greatly strengthened by the manometric test of Tobey and Ayer, described elsewhere (page 801).

The course of sinus thrombosis is irregular; it may be fatal in a few days or in two or three weeks. Death usually occurs from meningitis, brain abscess or pyemia. A few cases recover spontaneously, but the prognosis is grave unless the disease is so situated as to be accessible to operation.

The only successful treatment is surgical. The infected thrombus should be removed if possible. One which has broken down may be drained. Ligation of the vessels involved beyond the thrombosed area may check its spread. The most successful results are obtained with thrombosis of the lateral sinus. If the superior longitudinal sinus is involved, operation is more difficult. Little can be done with thrombosis of the cavernous sinus; the internal carotid artery may be ligated.

### CEREBRAL ABSCESS

Abscess of the brain is more common in children than in adults. It occurs at all periods of infancy and childhood and there are even undoubted instances of infection of prenatal origin.

**Etiology.**—Intracranial abscesses are nearly always secondary to infections existing somewhere else in the body and transmitted either by the blood stream or by direct extension. Hematogenous abscesses may be located anywhere in the brain, but the frontal, temporal and occipital regions are the favorite sites. Abscesses arise by direct extension from the mastoid cells or the paranasal sinuses. Although acute infections of these sinuses may occasionally be transmitted directly to the brain, it is usually the long-standing chronic infectious processes which lead to abscess formation. Chronic mastoiditis may lead to abscess in the temporal lobe or in the cerebellum. Infections of the frontal and the ethmoid sinuses usually extend into the frontal lobe of the corresponding side. Often there is no history but that of traumatism, which apparently acts in the development of a cerebral abscess as it occasionally does in the causation of osteomyelitis. Extensive burns are not infrequently followed by cerebral abscesses.

Any of the common pyogenic organisms may give rise to cerebral abscesses. Not infrequently very unusual organisms are found and at times it is impossible to cultivate any from the pus.



**Pathology.**—Most abscesses of the brain are located in the occipital, frontal, and temporal lobes, and in the cerebellum. Abscesses of the cerebellum are far less frequent than those of the cerebral hemispheres at all periods of life; this disproportion seems even greater in children. A very large percentage of intracranial abscesses are multiple. In size they vary from that of a small cherry to an orange. We have seen in infants both hemispheres almost replaced by numerous abscesses, only small patches of brain tissue remaining. Even the brain stem and cerebellum were studded with small abscesses.

The contents are usually thick, greenish-yellow pus, which may be fetid. When abscesses have lasted for some time they are usually surrounded by dense membrane. The pathological process may be slow, and may appear to be stationary for a long period.

Abscesses may rupture into the ventricles, less frequently upon the surface of the brain, causing meningitis; the pus may even escape externally through the auditory meatus.

**Symptoms.**—A brain abscess may produce no symptoms. We know of several instances of sudden death in which a chronic brain abscess was found at autopsy. More often local or general symptoms are present, the former due to the tumor and the latter to the infectious process. There is a great variability in the history, owing to the variety and virulence of the organisms. Abscesses may be classed as acute, subacute, or chronic. In acute forms associated with infection of a sinus or some other illness there is high fever, more or less continuous, severe headache, nausea, vomiting, drowsiness and delirium, and finally stupor merging into coma. There is usually a polymorphonuclear leukocytosis. Death may occur in three or four weeks or even less.

In the subacute type there is an acute onset which is followed in a few days or weeks by a period of relative calm, with a diminution of all of the symptoms but not usually complete freedom from them (latent period). Sooner or later the final period of intracranial pressure develops. In chronic abscesses an acute onset may be absent. In these cases the clinical history may be essentially that of tumor of the brain. In the latent period and even in the stage of pressure there are often indications that the lesion is inflammatory. There is apt to be a slight rise of temperature at the same time every day and some degree of leukocytosis. All such evidences may, however, be lacking.

The symptoms of the terminal stage are due to intracranial pressure, sometimes to rupture into the ventricle, and sometimes to meningitis. There is intense and continuous headache, often vomiting, stupor and finally coma. There may also be paralysis, delirium, and convulsions. If the terminal stage is due to meningitis, cervical rigidity, opisthotonos, and other evidences of inflammation of the meninges are present. Death from rupture into a ventricle is usually very sudden.

In infants there may be no symptoms except those of the intracranial pressure, in fact, cerebral abscesses without characteristic symptoms are not infrequently mistaken for hydrocephalus.

The local symptoms of abscess may be absent, indefinite, or very prominent, depending upon the position of the lesion. Abscesses of considerable size may exist



in the temporosphenoidal lobe, in the central part of the frontal lobe or in the cerebellum, without any definite local symptom. If the abscess is near the motor area there are the usual symptoms of disease in this location; spasm or paralysis of the face, arm or leg. Abscesses anywhere in the cerebral hemisphere are likely to cause convulsions. Abscesses in the cerebellum usually produce nystagmus, ataxia, and staggering gait. All these symptoms, however, may be absent. Papilledema is usually but not always present in cerebral abscesses. Localized pain and tenderness over the scalp and localized headache are often helpful in determining the situation of the lesion.

**Diagnosis.**—The most important general symptoms are fever, headache, delirium, and stupor. These become particularly significant when they follow otitis or trauma. The differential diagnosis of abscess is to be made principally from tumor, meningitis, and sinus thrombosis, and from these conditions more by the history and general course of the disease than by any special symptoms. The diagnosis of abscess from tumor is considered in connection with the latter disease. It is difficult to distinguish between meningitis and abscess since the two processes are often associated; focal signs favor abscess. With meningitis, cervical rigidity and Kernig's sign are more intense; the course is usually more rapid and more progressive, being rarely interrupted, as is the case with abscess. Leukocytosis is more constant and generally more marked in meningitis. An area of localized meningitis is commonly present in the vicinity of an abscess. The cerebrospinal fluid usually shows a moderate inflammatory reaction, a moderate number of polymorphonuclear leukocytes, a slight increase in globulin, but no bacteria. This is in sharp contrast to the findings in meningitis, in which the increase of cells is usually much more marked and organisms can easily be demonstrated in smear or culture. Sinus thrombosis is generally not accompanied by pressure manifestations; the fever is more irregular and chills are more frequent. The spinal fluid contains no bacteria and few white cells, but may be slightly yellow.

**Prognosis.**—The prognosis in cerebral abscess is always grave. Occasionally an abscess heals spontaneously, but this is not to be expected. The progress may be slow or rapid, but sooner or later the disease, if not interfered with, proves fatal.

**Treatment.**—The medical treatment of abscess in its active stage is that of any acute intracranial inflammation—ice to the head, absolute quiet, and full doses of morphine if pain is intense. Surgical treatment can be of little avail in fulminating abscesses. When they become walled off, they can be drained. In probably no other intracranial lesion is accurate diagnosis and precise localization so important for operative treatment. Lumbar puncture is useless and is, moreover, dangerous, since it is likely to cause spreading of the local area of meningitis which is often found in the vicinity of an abscess. When abscess is suspected the brain should be explored with a needle or ventriculography employed. Even after drainage is established these cases run a stormy course, fungating masses of brain tissue mixed with inflammatory products being discharged for many weeks. If recovery eventually occurs, the extent to which loss of functions may be regained is often surprising. Widespread paralyses and speech defects may disappear entirely, and the patient be left a normal or almost normal individual.



## MULTIPLE NEURITIS

This is a toxic-degenerative process, usually symmetrical and generalized. It is sometimes called "parenchymatous" polyneuritis to distinguish it from the less frequent "interstitial" neuritis, which is a true inflammatory process confined to one or two nerves.

**Etiology.**—The chief cause of multiple neuritis in children is diphtheria, although it is occasionally seen after other infectious diseases, especially malaria, typhoid, scarlet fever and mumps. There is also a condition called acute infective polyneuritis which follows a febrile illness of unknown nature after a latent period of a week or more. The obscure disease acrodynia, described elsewhere in this volume, is believed by some to be a polyneuritis. Cases are also described in which polyneuritis is associated with iridocyclitis, parotitis and an erythematous rash. Some cases of Landry's syndrome are to be regarded as a fulminating multiple neuritis. A rare type of recurrent polyneuritis of unknown etiology was described by Henry M. Thomas. Neuritis may follow injection of therapeutic sera and bacterial vaccines. In such cases there is usually a severe reaction with intense urticaria. There may be a general polyneuritis, or a single nerve or plexus may be involved. Nonbacterial poisons also cause multiple neuritis. The alcoholic type is rare in children but has been observed. Arsenical neuritis was formerly not uncommon as a result of treatment of chorea by Fowler's solution. Lead paralysis resulting from the ingestion of paint is by no means uncommon in childhood. Metabolic disturbances appear to play a small part in neuritis of childhood. Diabetic neuritis is rare, and beriberi is almost confined to the Orient. We have observed one of the rare cases of polyneuritis associated with hematoporphyrinuria.

**Pathology.**—The nerves tend to be affected more at their periphery than in their proximal portions. The myelin sheath suffers the most marked changes. With the Marchi stain it may be shown that the myelin is fragmented, and forms scattered droplets within the neurolemmal sheath. Lipoid globules are also seen in phagocytes which lie among the nerve fibers. The cells of the sheath of Schwann proliferate, as do the mesodermal elements of the connective tissue surrounding the nerve. By Bielschowski's silver stain it may be seen that there is usually little injury to the axis cylinders, which may persist unchanged when the myelin sheath is severely altered. In more advanced cases even the axis cylinders may be fragmented or may show spindle-shaped enlargements. There may also be pathological alterations of the motor cells of the spinal cord, although these are usually of mild degree.

**Symptoms.**—The toxic processes causing peripheral neuritis may involve other parts of the nervous system. Delirium and stupor may accompany severe intoxications. Only the symptoms resulting from involvement of the peripheral nerves will be described below.

The onset of multiple neuritis is in most cases a gradual one, it being usually from two to four weeks before the paralysis reaches its height. Very exceptionally the onset may be abrupt with fever, and marked paralysis appearing in a few days. It is characteristic of this disease that both motor and sensory symptoms are present,



and that they are the same in their distribution. The symptoms are usually symmetrical. There is first noticed a general weakness in the affected muscles, which slowly increases to complete paralysis. As the extensor groups of the hands and feet are apt to be affected, there is wrist drop and foot drop. The paralysis may begin in the feet and hands, and gradually extend until it involves not only the four extremities, but even the muscles of the trunk and the neck, although this is rare. The child is then absolutely helpless, unable to sit up or even to support his head. In such cases the head seems loosely attached to the body, and rolls about on the shoulders like a ball. Weakness of the spinal muscles leads to deformities which may be mistaken for Pott's disease, even by experienced observers. In most of the muscle groups the paralysis is incomplete. The symptoms which relate to the phrenic and the cranial nerves will be described with diphtheria, for they are rarely seen in any other form. It is characteristic of multiple neuritis that the bladder and rectum escape.

Sensory symptoms are marked only in the early stage of the disease, while the paralysis is increasing; they improve so much more rapidly than the motor symptoms that they may be altogether wanting at the time that the paralysis is at its height. In some cases they are so slight as to be overlooked. There is usually pain along the course of the affected nerves, which is sharp in character, and generally associated with acute tenderness of the nerve trunks and of the muscles. Often there is a general hyperesthesia in the early part of the attack, followed by partial anesthesia. The sensations of touch, pain, temperature and the muscular sense are all about equally affected.

Ataxia is not uncommon, and may be a more striking symptom than the loss of power. All the reflexes are diminished or lost, especially the knee jerk, as the legs are usually most affected. Sometimes, particularly after diphtheria, there is loss of the knee jerk when there is no other symptom of neuritis. In the severe cases muscular tremor is frequently present.

Atrophy is a prominent symptom of neuritis and is evident early in the disease, often being quite as rapid as in poliomyelitis. The electrical reactions are altered—every grade of reduction in the responses being seen, from a slight diminution in the reaction to faradism, to the complete reaction of degeneration. Vasomotor symptoms, such as edema of the affected parts, glossiness of the skin, etc., are often present. Deformities from muscular contractions occur early; they may be severe, and in some cases permanent.

**Course and Prognosis.**—The usual course of the disease is for the symptoms gradually to increase for three or four weeks and then to improve, sometimes rapidly, but more often slowly, the case usually going on to complete recovery in the course of a few months. Exceptionally the paralysis may be permanent. The sensory symptoms always disappear before the motor ones. Multiple neuritis may prove fatal from paralysis of the muscles of respiration, or death may be due to asphyxia from the entrance of food or foreign bodies into the air passages, owing to anesthesia of the epiglottis and paralysis of the muscles of deglutition. Death sometimes follows from complications, especially pneumonia. The electrical reactions are of prognostic value. If the reaction of degeneration is present the paralysis is certain to last many months, and may be permanent. Where there is



simply a diminution of the faradic responses, even though accompanied by marked atrophy, complete recovery may be expected.

**Diagnosis.**—The diagnostic features of multiple neuritis are the combination of motor and sensory symptoms with the same distribution, the occurrence of atrophy, and the diminution in the electrical responses, even the reaction of degeneration. The gradual onset, the widespread distribution of the paralysis and the tenderness of the muscles are also characteristic. If all four extremities are paralyzed, it is altogether the most probable disease; and if to this is added paralysis of the neck and spinal muscles, the diagnosis is almost certain. The fact that the paralysis is often incomplete, and that it involves parts distant from each other, is also important. Neuritis may be mistaken for poliomyelitis, or for Pott's paraplegia; an important diagnostic point from the last mentioned is the condition of the reflexes, which are as a rule greatly exaggerated in Pott's paraplegia, but diminished or lost in multiple neuritis.

**Treatment.**—As this disease tends in the great majority of cases to spontaneous recovery, it is difficult to estimate the value of any method of treatment. Causes such as lead, arsenic, alcohol, and malaria, are to be sought and removed as the first step. During the acute stage the pain may be so severe as to require relief, which is best accomplished by the application of heat. Strychnine is much used, but it is doubtful whether it has any specific influence, although as a tonic it is valuable. Massage is beneficial. The special treatment of respiratory paralysis is discussed in connection with poliomyelitis.

## INTERSTITIAL NEURITIS

This condition is rare in children and little is known about its cause. In contrast to the multiple or polyneuritis described above, it is confined to one nerve or a group of nerves constituting a plexus. Brachial plexus neuritis is not rare; sciatic neuritis, although common in adults, is decidedly rare in children. Any peripheral nerve may be affected.

The lesions are described as follows: The nerves are swollen and red, and more or less infiltrated by round cells. The connective tissue of the nerve sheath is proliferated. The vessels are engorged and their walls filled with cells of various types. There is a variable degree of myelin destruction, but the axis cylinders are more resistant and tend to persist. These changes are interpreted as due to a true local inflammatory process involving the interfascicular and perineural connective tissue; it is hence sometimes called perineuritis.

Infections both focal and local are to be blamed for most cases, although trauma and exposure to cold may play a part. Frequently the involved nerve passes near an inflamed joint or abscess, and it seems likely that the inflammatory process has extended to the nerve. Sciatic neuritis due to lumbar arthritis is an illustration of this possibility. In many cases the cause cannot be assigned with confidence.

The symptoms include loss of function of the involved nerves with paralysis, atrophy and sometimes anesthesia, usually associated with severe pain and tenderness of the nerve trunks. Reflexes may be lost. There is always a strong tendency to improvement or recovery, although the course may be a long one. All possible



foci of infection should be investigated and treated appropriately. The affected limb should be placed at rest in a splint. Massage and passive movements may be employed as soon as pain and tenderness have disappeared. When power begins to return to the paralyzed muscles, brief exercises may be advised, but fatigue should be carefully avoided.

### PERIPHERAL FACIAL PARALYSIS

Peripheral paralysis of the face occurring as a result of injury inflicted during delivery has already been described. There remain to be considered those cases which result from causes operating at a later period. In many of these, perhaps

half, no cause can be assigned, and the term Bell's palsy is vaguely applied to the group. The facial nerve is paralyzed in perhaps forty per cent of all cases of tuberculous disease of the petrous bone. In such instances there is usually a chronic discharge from the ear, and some deafness. Acute otitis and mastoiditis rarely cause facial paralysis, but the nerve is frequently injured in operations for mastoiditis. Occasionally facial palsy may occur as a result of mumps or of disease of the regional lymph nodes. Basilar meningitis and posterior fossa tumors may affect the nerve in its intracranial course. Fracture of the base of the skull sometimes causes laceration of the nerve in the bony canal.



FIG. 135.—FACIAL PARALYSIS, FOLLOWING TUBERCULOSIS OF THE MIDDLE EAR, TUBERCULOUS ADENITIS.

Marked facial paralysis is easily recognized. It is important to separate the peripheral paralysis from that due to nuclear lesions and types due to lesions above the pons, as in cases of ordinary hemiplegia. Nuclear lesions are usually associated with paralysis of the sixth nerve. The electrical responses are affected in both the peripheral and nuclear types. With supranuclear lesions only the lower half of the face is affected; the muscles of the forehead and those about the eyes escape, and the electrical reactions are unchanged.

The prognosis in cases of facial paralysis is, of course, dependent upon the nature of the pathological process. When middle ear disease is responsible the outlook is not very favorable; although there may be improvement, as a rule some paralysis persists. With brain tumors no improvement is to be expected. In basilar meningitis, however, facial palsies may be very transient. Local inflammations such as mumps and inflamed lymph nodes in the course of the nerve, as a rule, leave no residual paralysis. The prognosis in the obscure cases is variable. Some of these clear up entirely in the course of time, while others persist.

The treatment is essentially the same as in other cases of neuritis. In cases due to ear disease the primary lesion should receive appropriate treatment.



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## CHAPTER CXV

### PROGRESSIVE DEGENERATIONS OF THE NERVOUS SYSTEM

These conditions depend upon inherited factors or defects of the germ plasm, for similar or identical symptoms commonly occur in siblings, collaterals or ancestors. In some families the inheritance follows mendelian laws, either as a dominant or recessive characteristic. The morbid factor may be transmitted by parents of only one sex or by either sex. In many instances, however, the disease is not transmitted according to any simple law, and it must be admitted that the mode of inheritance is still obscure. It may be said of this whole group that the development of the nervous system seems to be quite normal up to the point at which the loss of function begins. The onset is characteristically so insidious that it can rarely be dated accurately. The process may involve the nervous system as a whole, as in the infantile cerebromacular degeneration; or may be selective as in Wilson's disease. Gowers believed that there is a lack of vital resistance of the nervous system and applied the term "abiotrophy" to the whole group. Numerous abortive and transitional cases are observed, and very different syndromes appear within the same family. Indeed, no two affected families ever show exactly the same symptoms and an almost infinite variety of syndromes have been described, for many of which we can find no satisfactory names. The question may well be raised whether the classical pictures really represent true disease entities or should be regarded as merely useful symptom groups.

### CEREBROMACULAR DEGENERATIONS

Several types are described and the term cerebromacular degeneration seems a good one for the whole group. The infantile form has been termed Tay-Sachs disease, or *amaurotic family idiocy*, although it is not a form of idiocy, but a progressive and uniformly fatal disease. It is confined almost entirely to the Jewish race. It shows a strong familial tendency, often two or three and sometimes even four or five children in the same family dying of the disease. There are no other known etiological influences.

The first symptoms are usually noticed between the sixth and tenth months, up to which time the infant has generally appeared normal. At first it is only noticed that the child is making no progress in his development, or that his eyesight is not so good as formerly. He does not gain in ability to sit up or to use his muscles; he lies quietly, does not respond as he once did, and takes less interest in his surroundings. After a few weeks it is clear that the child, instead of advancing, is actually retrogressing both physically and mentally. His muscles become so weak that he can no longer sit up or even hold up his head. Vision becomes less and less distinct; the child no longer recognizes the faces of friends or objects shown him. Finally, he becomes dull, apathetic and quite indifferent to his surroundings;



then it is evident that he cannot see at all. In the early stages the muscles are usually weak and flaccid; later there is rigidity with increased knee jerks and often, marked spasticity. Children with amaurotic family idiocy are often fat and well nourished, but with the onset of weakness loss of weight occurs and eventually this may be extreme. There may be general convulsions. The most characteristic feature of the disease is revealed by the ophthalmoscope. Occupying the place of the macula lutea there is a large milky blue or white area with a bright cherry-red spot in its center. With this there is also atrophy of the optic disks. The ocular changes are symmetrical.

The outlook is absolutely bad. The disease is progressive and usually fatal within a year from the time when the first symptoms are seen; but occasionally the blind, helpless child may live for several years if feeding with the stomach tube is resorted to, for swallowing eventually may become quite impossible.

There are characteristic pathological changes to be found in the cells of the central nervous system. The brain itself is not diminished in size, but is more firm and elastic than normal. The same is true of the cord. Microscopically, the ganglion cells show a marked and striking degeneration. They are swollen, their protoplasm is undifferentiated and the nucleus is eccentrically situated and degenerating. There are oftentimes large, ovoid swellings upon the cell processes. Ultimately the nerve cells disappear and are replaced by neuroglia. These changes are very widespread and are present throughout the hemispheres, brain stem and spinal cord. In many cases hardly a normal ganglion cell can be found. Like the ganglion cells of the brain and cord, the retinal nerve cells are everywhere swollen and degenerated, but it is only in the macular region where these cells are thickest that this change becomes grossly apparent. Here the dense layer of opaque degenerated cells completely obscures the pink color of the retina beneath. At the fovea, ganglion cells are absent, revealing the normal retina as a cherry-red spot, unobscured by degenerated tissue.

A juvenile form is also described but is very rare. This type is not confined to the Jewish race, as is the rule in the infantile form. It attacks several children in a family at about the age of six or seven years. These children become dull, stupid, lose their power of attention and eventually their ability to read, speak and even recognize people. With these symptoms there is a central scotoma which may be of high degree but does not produce complete blindness. The physical condition of the child may remain normal for a long time. The eyes show a combination of atrophy of the retina with pigmentation, especially in the region of the macula. The condition is incurable. It is progressive, though the patients may live many years. Death occurs from intercurrent infection rather than from the disease itself. It is probable that lipoid cell splenomegaly (Niemann-Pick disease) is closely related to amaurotic family idiocy. It shows a predilection for the Jewish race. Nervous symptoms and ocular lesions are sometimes found quite similar if not identical with those found in Tay-Sachs disease.

## ENCEPHALITIS PERIAXIALIS DIFFUSA

So many cases of this strange malady, first described by Schilder, have been observed in recent years that it merits inclusion among the nervous diseases of



childhood. Although some doubts may still be entertained that it is a disease entity, the lesions are sufficiently characteristic to set it apart from the other diffuse cerebral degenerations.

The pathological changes are confined to the subcortical white matter of the brain, and the lesions are usually of massive proportions, often involving the greater part of a whole hemisphere. The cortex is not affected and is separated from the lesions by a thin layer of intact white matter, the arcuate fibers. Fresh lesions are soft and spongy, but old lesions may be very dense. Small foci may be found in the brain stem and basal ganglia, but are always of secondary importance. Histological studies reveal that the myelin sheaths of the nerve fibers are primarily affected; intact axis cylinders may be found in completely demyelinated areas, although they too are also eventually destroyed. In regions where the process is active, lymphocytes and even plasma cells are collected about the small vessels, and fat-laden phagocytes are almost always present in great numbers. There is active proliferation of the fibrous glial cells, which results in dense gliosis if the process continues long.

The symptoms are subject to such great variation that it is really impossible to outline a clinical picture except in the broadest terms. In some instances there are several cases in the same family. The onset is relatively acute and hemianopia or even cortical blindness may be the first symptom. This is explained by the fact that the occipital lobes are often the seat of the initial lesion. Spastic paralyses, either hemiplegic, monoplegic or bilateral soon appear. In some cases there is hemianesthesia and hemiataxia attributable to involvement of the parietal lobes. Deafness also occurs and points to bilateral lesions in the temporal white matter. Convulsions are often present. Mental changes occur early, lead to dementia and culminate in stupor. Before the end practically all cerebral functions are abolished. A remarkable feature of some cases is the presence of papilledema and symptoms of increased intracranial pressure, which is apparently due to swelling of the brain. The course is progressive, but remissions are not unknown. Indeed, apparent arrest of symptoms for many years is described. The average duration is about one year, but the course may vary within wide limits. Spinal fluid changes are not striking. Pressure may be high and the globulin is moderately increased, but the cells are not affected. Ventriculography may be the only method of ruling out a brain tumor.

The outlook is almost hopeless and no treatment is known.

### HEPATOLENTICULAR DEGENERATIONS

The essential features of this group include progressive degeneration of certain parts of the brain, especially the basal ganglia, and nodular cirrhosis of the liver. The course is progressive, but death may be long deferred. The prognosis is always bad. The onset is usually in the second decade, but may occur earlier. A familial incidence is very striking; rarely the condition is hereditary. Several clinical pictures are known.

**Wilson's Disease.**—The picture described by Wilson in 1912 was that of gradually increasing tremor, increased by excitement and by voluntary effort, progressive rigidity of the muscles leading to complete helplessness, and severe



disturbances in deglutition and articulation. The facial expression is fixed. There may often be a rigid smile and the mouth may be held wide open. Choreiform and athetoid movements are absent. The tendon reflexes are unchanged and the plantar reflex is normal. In most cases there is no dementia, but emotional instability and minor mental changes occur. Involuntary laughter is described. The hepatic cirrhosis is usually asymptomatic, but recently cases have been described in which fever, vomiting, hematemesis, jaundice and ascites preceded the development of nervous symptoms. A remarkable diagnostic sign known as the Kaiser-Fleischer zone is sometimes observed. This is a narrow zone of golden yellow pigmentation on the posterior surface of the cornea near the limbus. It is best demonstrated by the slit-lamp. This may constitute the first evidence of the disease. The course is slowly progressive and ends fatally in two or three years. Cases are described which run a more acute course with slight fever and terminate within a few months. Recurrent attacks resembling tetany occur in such cases.

From the above description it is evident that the nervous symptoms are almost identical with those of Parkinson's syndrome, and indeed it may be impossible to distinguish Wilson's disease from the parkinsonism following epidemic encephalitis unless hepatic cirrhosis or pericorneal pigmentation can be demonstrated.

The corpus striatum is chiefly affected, the most advanced changes being in the putamen. In some cases the latter is completely necrotic and represented by a cavity. The globus pallidus and caudate nucleus are only mildly affected, but the ansa lenticularis is degenerated and the corpus luyssii is shrunken. With careful modern methods pathological changes can also be found in many other parts of the brain but these are of mild degree. The liver shows advanced nodular cirrhosis and on microscopic examination there are areas of necrosis and areas of regeneration. The spleen may be enlarged.

Since Wilson's original description it has been found necessary to include other syndromes among the manifestations of this disease. *Dystonia musculorum deformans* must be included in this group, for some cases are associated with cirrhosis of the liver. This is a most bizarre disorder. It is most common in Russian Jews, but not confined to them. It is characterized by slow involuntary movements of a twisting, writhing nature. These involve the extremities, neck and body, but usually spare the face and bulbar segments. Apart from the movements there are disorders of muscle tone, which may be either increased or diminished. Distorted postures result: lordosis, scoliosis, kyphosis, and various types of clubfoot. Contractures of the muscles fix the body in these abnormal positions. In severe cases the child may be quite helpless, although there is no paralysis, for any effort merely results in the accentuation of the involuntary movements. The gait is characterized by excessive lordosis. Tendon reflexes are normal when the hypertonus does not make it impossible to demonstrate them. A type is also described in which there are merely disturbed postures and no involuntary movements. Few postmortem studies have been made; these have revealed nervous lesions much more diffuse than those of Wilson's disease but of similar nature. Cirrhosis of the liver is usually present.



**Progressive Double Athetosis.**—In some cases the involuntary movements are of the nature of mobile spasm, or double athetosis. This syndrome has been described above and will be merely named here. It is important to emphasize that it is progressive, in contrast to congenital double athetosis which is usually due to a defect of development.

**Pseudosclerosis.**—This name has been applied to an ill-defined group of cases supposed to resemble multiple sclerosis, but found to depend upon lesions characteristic of lenticular degeneration although more diffuse than those first described by Wilson. There is also hepatic cirrhosis, and the Kaiser-Fleischer zone of pericorneal pigmentation is present. Indeed, it was in a case of pseudosclerosis that this zone was first observed. The clinical significance of this term is so vague that it has no real value and serves merely to illustrate that a variety of syndromes may occur in hepatolenticular degenerations.<sup>1</sup>

## UNDIFFERENTIATED CEREBRAL DEGENERATIONS

The three disease groups described above, namely, encephalitis periaxialis diffusa, cerebromacular and hepatolenticular degenerations, are all characterized by specific histological lesions. It is important to keep in mind that these types do not exhaust the possibilities and that there is also a large heterogeneous group of cerebral degenerations not yet differentiated into separate entities. It may be said of this group as a whole that the process consists of degeneration of the cerebral neurons with reactive overgrowth of the glial fibers, causing increased density of the brain. Hence, the old name, "progressive cerebral sclerosis." The symptoms are similar to those of the above groups: mental deterioration, progressing to dementia, spasticity and weakness of the limbs, visual disturbances, bulbar symptoms, convulsions and death after a long period of invalidism.

## FRIEDREICH'S ATAXIA

Friedreich's ataxia is a hereditary degeneration of the nervous system beginning early in childhood, usually between the fourth and seventh year. It is a rare condition. While cases are encountered with no history of a like condition in relatives, the disease is especially likely to attack several members of a family in one or more generations. As many as eight sufferers from the disease in one generation have been reported, and it has been traced through three generations.

The pathological changes are chiefly in the cord. These consist in a diminution in the circumference of the cord throughout its entire extent and in a degeneration of various tracts, chiefly the posterior columns. The column of Goll is affected throughout, the column of Burdach to a greater or less degree, and the crossed pyramidal tract to a slight extent. In addition, the cells of Clarke's column are degenerated and there is a consequent degeneration of the direct cerebellar tract and the bundle of Gowers. The cells of the anterior horns are unaffected.

Ataxia is the most striking and usually the earliest symptom. It is first noticeable and is always most marked in the legs. There is difficulty in walking and

<sup>1</sup> Three cases in one family have recently been described by Lhermitte and Muncie in which there were evidences of liver disease associated with the typical corneal pigmentation in the absence of definite nervous symptoms. Hence, we must expect to see the disease make itself known either by nervous symptoms, hepatic symptoms or by corneal pigmentation.



even in standing, but the ataxia of the legs is noticeable in any position, even when lying down. The children stand with their legs wide apart. In some instances there may be a distinct Romberg symptom, it being impossible for them to stand at all with the eyes closed. The gait is ataxic, much like that of locomotor ataxia at first, but later it may be so disturbed that the patient reels from side to side as if intoxicated. Eventually locomotion is impossible, especially when the muscular weakness, which is regularly present, becomes extreme with atrophy. Early in the disease muscular weakness is slight. There may be wobbling of the head and there is usually a coarse tremor of the arms and hands. Sensation is well retained and control over the bladder and rectum is normal. Exceptionally there are sharp, lancinating pains in the legs. The knee jerks are commonly absent. Slow, scanning, sometimes explosive speech is very frequent, and late in the disease speech may be nearly impossible. There is often a marked nystagmus. A striking symptom is deformity of the foot, which may be one of the first symptoms to be noticed. The foot appears shortened; it is markedly arched and is held in a position of slight equinovarus. The great toe is hyperextended and sometimes the terminal phalanx is flexed. Kyphoscoliosis develops with the advent of muscular weakness. The intelligence is well retained for a time but ultimately suffers deterioration.

The course of the disease is progressively downward. The patient eventually becomes bed-ridden, but the progress of the disease is very slow. It may last twenty or thirty years or more. Death is usually due to some intercurrent disease. Friedreich's ataxia is incurable.

### PROGRESSIVE CEREBELLAR ATAXIA (MARIE)

Closely related to Friedreich's ataxia is the rare progressive cerebellar ataxia of the Marie type. It is seldom seen before the twentieth year. There is usually a history of similar symptoms in relatives. Unlike Friedreich's ataxia, in which the symptoms point to injury of the cerebellar tracts, the pyramidal tracts and the posterior columns, the symptoms in the Marie type are purely cerebellar.

### PROGRESSIVE SPASTIC PARAPLEGIA

This is a heredofamilial condition resulting in slowly progressive weakness and spasticity of the legs, with exaggeration of the tendon reflexes, ankle clonus and extensor plantar response. There is usually no disturbance of sensation, atrophy of the muscles or loss of sphincter control. In typical cases there is no ataxia and no mental change. However, many variations in the clinical symptoms exist and transitional cases connect this syndrome very closely with Friedreich's ataxia and with the progressive cerebral degenerations. The lesions in uncomplicated cases are confined to the crossed pyramidal tracts in the lumbar cord.

### PROGRESSIVE MUSCULAR ATROPHY

A number of diseases in infancy and childhood are accompanied by muscular wasting. This may be secondary to disturbances of nutrition, to some chronic infection, or it may result from disuse. Wasting is also present with organic diseases of the nervous system, particularly as the result of some acute lesion



such as poliomyelitis, and also with chronic crippling diseases such as spastic paraplegia, chronic meningitis, etc. But there is a group of diseases in infancy and childhood that is characterized by progressive muscular wasting and weakness alone. They develop insidiously and with but few exceptions progress uninterruptedly to a fatal termination. They are of great chronicity and are quite incurable. Many show a marked hereditary tendency.

The two principal varieties of progressive muscular atrophy are the spinal and the neural form.

**Spinal Muscular Atrophy.**—*The Werdnig-Hoffmann Type.*—This disease is markedly hereditary; several children in a family may be affected, and the disease has been traced through two or three generations. It is not a common condition—only thirty or forty cases in all have been reported. The onset is early, usually toward the end of the first year. A weakness in the thighs and back develops in a child who up to that time has been entirely normal. This weakness extends so as to involve the shoulders, the neck, and eventually the arms and thighs. The legs and lower arms are only involved late in the disease, and the hands and feet rarely at all. There is marked atrophy of the muscles, particularly those of the pelvis and shoulders. The muscles show at times fibrillary contractions and there is always loss of deep and generally of superficial reflexes. There is a great diminution in response to both faradic and galvanic currents. The muscles of the face usually escape entirely. Bulbar symptoms are very unusual. Speech is normal and the mentality remains unaffected to the end. There is no interference with sensation. The progress of the disease is quite rapid. Death usually results in two or three years, from respiratory involvement or from pneumonia. The localization of the chief muscular paresis and atrophy in the pelvic and shoulder girdles, the progressive character of the disease and the retention of a clear mentality distinguish it from the other diseases with which it is likely to be confounded, such as amyotonia congenita, poliomyelitis, progressive neural muscular atrophy and amaurotic family idiocy. The progress of the disease is rapid. It is unbroken by periods of remission, and the outlook is hopeless. No treatment has any effect.

The pathological changes are clearly marked. There is an atrophy of the spinal cord, with degeneration of the cells in the anterior horns throughout its whole extent from the medulla to the cauda equina. Secondary to this is a degeneration of the anterior roots of the cord and of the motor nerves, with great atrophy of the muscles. There are no changes in the pyramidal tracts.

*Familial Spastic Paralysis with Atrophy.*—This condition closely resembles the common amyotrophic lateral sclerosis of adults but, unlike that disease, usually affects a number of children of the same family, and may occur in several generations. It is characterized by atrophy starting in the small muscles of the hands and progressing to the arms and shoulder-girdle, and by spasticity and weakness of the legs. The course is slowly progressive. At autopsy degeneration of the pyramidal tracts and atrophy of the motor cells in the anterior horns of the spinal gray matter are found. The disease is very rare. Chronic progressive bulbar palsy, a common form of spinal muscular atrophy in adults, does not seem to occur in childhood.

**Neuromuscular Atrophy.**—*Peroneal Type* (Charcot, Marie, Tooth).—This form of muscular atrophy exhibits as marked familial tendencies as any other



known disease. Examples of it have been met with in five generations and it is seldom confined to one member of a generation. Herringham has recorded a family in which 26 members had been afflicted with the disease. The onset is generally after the sixth year. It begins slowly and symmetrically in the distal parts of the extremities, usually the legs. The extensor longus hallucis, the extensor longus digitorum and the tibialis anticus are usually the first muscles to waste; afterward the peroneal group. The localization of the muscular weakness causes inability to flex the foot, which hangs down, causing an impediment to walking. To overcome the impediment the feet must be lifted too high, which causes the "stepping" gait. Double clubfoot, in the position of equinovarus, often results from unopposed muscular action. On this account many of the cases first come to the attention of orthopedic surgeons. It is uncommon for the disease to begin in the hands, but instances of such a mode of onset have been reported. The atrophy then affects the small muscles of the hands. As the disease progresses the legs and forearms gradually become involved, but the thighs and upper arms remain free. There is no hypertrophy of muscles or pseudohypertrophy. There may or may not be fibrillary twitching of the muscles. The deep reflexes of the affected extremities are either diminished or absent. Sensation may be normal or there may be complaint of paresthesia, or of feelings of heat and cold. Shooting pains may be felt, but the pain is never very severe and is frequently entirely absent. Control of the bladder and rectum is complete. There is a diminution of response to both the faradic and galvanic currents in the affected muscles, and in certain instances this may obtain in muscles which are apparently normal.

The course is an exceedingly slow one and usually not continuously progressive. In this regard it differs greatly from the allied conditions. The disease seldom results in death and many patients live an active, self-supporting life for years. No known treatment arrests the progress of the disease. Orthopedic treatment (tenotomy, braces, etc.) is of marked aid in preserving the ability to walk.

The nerves in the peroneal type of muscular atrophy are almost always the seat of a marked interstitial hyperplasia. Associated with the neural change is a degeneration of the posterior columns of the cord and a marked atrophy of the muscles involved. Here, as in all these allied diseases, exceptions may be found in a preponderant alteration in the cord and muscles and an almost complete escape of the nerves.

*Hypertrophic Interstitial Neuritis.*—This was described by Déjerine and Sottas. It occurs in children and young adults and is strongly familial. In addition to muscular atrophy, as in the neural type, there are shooting pains, ataxia, scoliosis, nystagmus and, most characteristic of all, palpable enlargement of the peripheral nerve trunks. This type is very rare and hence of little practical importance.

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## CHAPTER CXVI

### NEOPLASMS INVOLVING THE NERVOUS SYSTEM

#### CEREBRAL TUMORS

Tumors of the brain are among the most common tumors of the body at all ages, although somewhat less frequent in childhood than in adult life. About 14 per cent of all brain tumors cause symptoms before the age of fifteen, and the early appearance of some of them makes it probable that they arise *in utero*. Tumors similar in location and histology may occur in identical twins.

Gliomata constitute about 75 per cent of the brain tumors of childhood. Almost half of these are slow-growing, relatively benign growths composed of astrocytes and often cystic. Their usual location is in the cerebellum. In the recent classification of Bailey they are termed *astrocytomata*. The next largest group is a very cellular tumor of embryonic type. They arise in the roof of the fourth ventricle and are called *medulloblastomata*. These growths have marked invasive qualities and in rare instances may break into the fourth ventricle and become disseminated throughout the subarachnoid spaces, producing the condition formerly called "sarcomatosis of the meninges." Nearly one-third of the gliomata belong in this group. Another type of glioma, the *spongioblastoma multiforme*, is of somewhat varied histological structure, but uniformly runs a rapid course and soon recurs after operation. It is less frequent than other types and includes only about 6 per cent of the gliomata. Unlike the above-mentioned groups it is usually cerebral. *Ependymomata* are also uncommon. About 10 or 15 per cent of the tumors of childhood arise from Rathke's pouch and are therefore found in the region of the sella turcica, where they often compress the optic chiasm. They are epithelial cysts filled with yellow fluid which often contains cholesterol crystals. They usually show areas of calcification demonstrable in roentgenograms. Some of the common tumors of adult life, such as the acoustic neuromata, "dural endotheliomata" and adenomata of the pituitary gland, are very rare in childhood, but all of these are occasionally found. Pineal growths are of great interest but also rare. Angiomata, dermoids, teratomata, sarcomata and metastatic growths are sometimes found.

Although not neoplasms, gummata and tuberculomata are often considered with them because of the similarity of their symptoms. Gummata are exceptionally rare, but tuberculomata are fairly common. The latter are often multiple and like other tumors in childhood affect chiefly the cerebellum and brain stem. They are always secondary to tuberculosis elsewhere, usually of the lungs and of the bronchial lymph nodes. They most frequently start from the membranes, rarely being centrally situated, and extend inward, infiltrating the superficial portion of the cerebellum or cerebrum. There is almost invariably localized menin-



gitis at the site of the tumor; there may be adhesions between the dura and pia mater, and the disease may extend to the cranial bones. In size these tumors vary from a small pea to a child's fist. They may be softened and broken down at the center, or caseous throughout. They are the result of a localized tuberculous inflammation, which does not differ essentially from that seen in other parts of the body. They rarely undergo calcification.

The growth of cerebral tumors often leads to secondary changes. These are the result of pressure upon adjacent parts of the brain, or of obstruction to the ventricular system causing hydrocephalus. Tumors in the posterior fossa almost invariably produce hydrocephalus. Hemorrhage occasionally occurs in a tumor.

**Symptoms.**—These may be divided into two groups: First, the general symptoms, which are due to pressure and are more or less independent of location; secondly, the local symptoms depending upon the situation of the growth.

Of the *general symptoms* one of the most frequent is headache. Though it varies much in its character, it is rarely absent. It may continue for a long period, or it may be intermittent.

Vomiting is next in importance. Though at times projectile it is usually not characteristic. It may occur at any time, but most often when the headache is at its maximum.

General convulsions are common in cerebral tumors but are rare in cerebellar. Their frequency and severity varies but they are apt to be more frequent and severe as the disease progresses. All degrees of severity are seen, from slight twitching and temporary loss of consciousness to typical epileptiform seizures.

Mental symptoms are usually not striking, though fretfulness and irritability are often present. Change of disposition may also be observed. All of these symptoms are so frequent from other causes in children that they excite no apprehension, unless to them are added dullness, apathy and somnolence.

Papilledema (choked disk) occurs in over 90 per cent of brain tumors. It may be associated with no disturbance of vision until later, when optic atrophy appears. Choked disk is usually double. It is more constant and severe in tumors of the cerebellum, owing to the more rapid development of hydrocephalus; but it should be remembered that choked disk, though one of the most important objective evidences of tumor, is a late manifestation and its absence is not an argument against the presence of tumor.

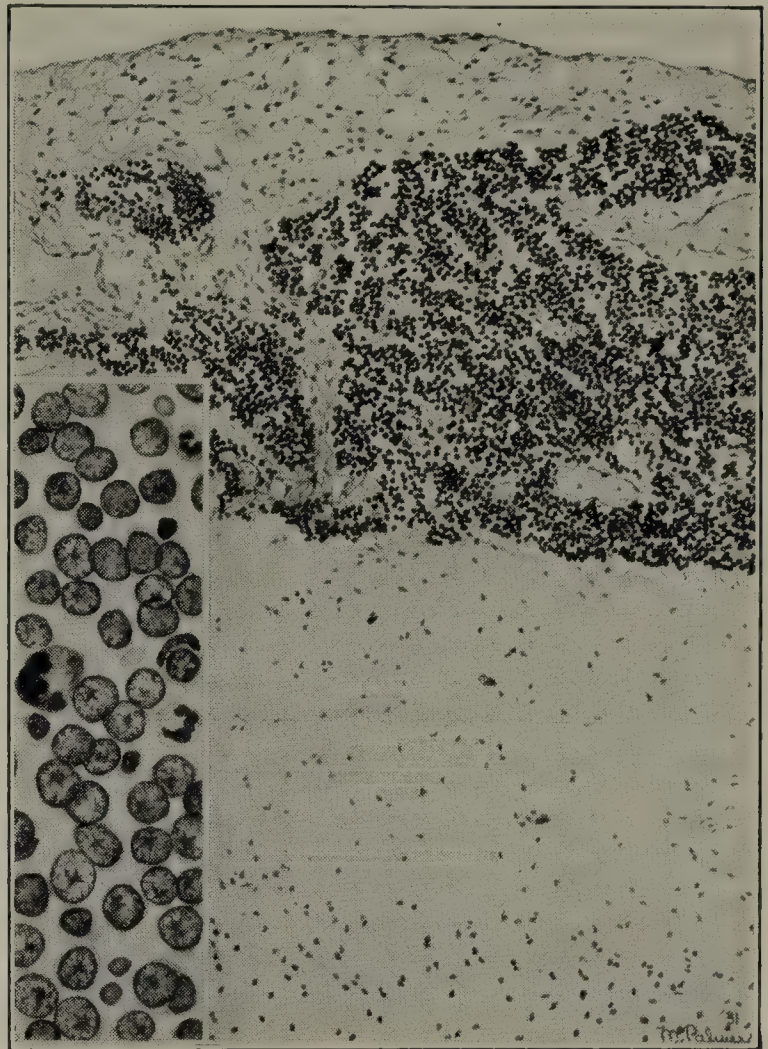


FIG. 136.—MEDULLOBLASTOMA IN SYLVIAN FISSURE.



Vertigo is a common complaint with older children and seems to be present irrespective of the location of the tumor. A slow pulse is often observed with brain tumors. It may be as low as forty or fifty to the minute. This is the result of increased intracranial pressure.

Some degree of enlargement of the head is present, depending upon the extent to which the sutures yield to the intracranial pressure. It is therefore most marked in young children and in those in whom hydrocephalus develops rapidly.

*Local Symptoms.*—These may be irritative or destructive; they may be wanting entirely. Great variations are seen in different cases, even with tumors in the same location. The variety of clinical pictures which can be produced by brain tumors is almost endless.

**Diagnosis.**—Brain tumor should always be considered in the presence of cerebral symptoms, if only because of its frequency. It has been our experience that the majority of obscure neurological cases have eventually proved to be neoplasm. The symptoms of tumor may be simulated by abscess, encephalitis, or any of the various degenerative diseases of the brain. Although it is often possible to make an exact topical diagnosis, the methods of localization give little information as to the nature of the process, whether it is inflammatory, degenerative or neoplastic.

An abscess may be suspected if there is a history of trauma or of chronic ear or sinus disease; the presence of fever or leukocytosis suggests an inflammatory process, though these signs may not accompany one. The demonstration of multiple lesions is against abscess or tumor; the majority of tumors are single. A striking exception to this rule is to be found in the case of medulloblastoma, which sometimes spreads over the meninges and may simulate a low-grade meningitis both clinically and in the spinal fluid findings.

An insidious onset is characteristic of most tumors, but does not distinguish them from degenerative diseases or from many cases of encephalitis. An acute onset is against tumor, but occasionally such a history is obtained, as when symptoms are produced by hemorrhage from a tumor. As is the case with most other diseases of the nervous system, a history of a fall at the onset, with supposed injury to the head, is exceedingly common and probably of little significance.

A progressive downward course is one of the characteristics of a tumor; it may be rapid, death occurring within three weeks, or it may last five years or more, depending upon the nature and situation of the growth. Tumors of the brain stem are likely to be rapidly fatal. Temporary remissions and exacerbations of symptoms are rarely seen in tumor and occur only when there is bleeding.

The spinal fluid may give valuable evidence in the differential diagnosis of brain tumors. Except for certain rare instances of medulloblastoma, an increase in cells in the spinal fluid does not occur. Globulin may, however, be present in considerable quantity with rapidly growing tumors. The presence of old blood in the fluid should suggest pachymeningitis hemorrhagica rather than a tumor, for hemorrhage from the latter into the subarachnoid space is less frequent.

Evidences of intracranial pressure are of great help in ruling out the degenerative diseases, but do not help in distinguishing tumors from abscesses or other inflammatory processes.



**Localization.**—A familiarity with the methods of cerebral localization is essential, if one is to determine the exact location of a tumor. These are described in current works on neurology. Ventriculography has proved a valuable aid in intracranial diagnosis; it is particularly useful in the case of tumors.

**Prognosis.**—The prognosis in tumors is uniformly bad; their course is usually continuously downward; sudden death is not very infrequent. Occasionally symptoms may be arrested for months and even a year. We have seen several cases with all the characteristics of tumor, including papilledema, which recovered entirely. No distortion of the ventricles was, however, present. Their nature is unknown. Tuberculomata may remain stationary for long periods of time; rarely calcification with recovery takes place. This is, however, distinctly unusual; the larger tuberculomata almost invariably terminate with meningitis.

**Treatment.**—Successful extirpation of brain tumors has been and doubtless always will be infrequent. The tumors are usually infiltrating and cannot be removed *in toto*; the operative mortality is high. The best outlook is with cysts. Without operation the result is so uniformly fatal that if there is any possibility of removal of the growth it should be attempted. If enucleation is impossible, decompression may give symptomatic relief and preserve the sight for a long time. Radium may be tried.

## TUMORS OF THE SPINAL CORD

Tumors of the spinal cord are exceedingly rare in children and almost unknown in infancy. They arise from the bone, from the meninges, or from the nervous tissue itself. The commonest tumors are sarcomata, fibromata, gliomata, tuberculomata and lastly gummata.

The first and most important symptom is usually pain. This may appear in the extremities or form a girdle around the trunk, and always corresponds to the distribution of a spinal root. The next development is usually weakness and spasticity of the legs; still later loss of sensibility appears, which eventually extends up to the level of the pain. In infants it may be impossible to demonstrate sensory loss satisfactorily. Loss of sphincter control is in most cases a late symptom. The tendon reflexes are increased; there is a bilateral ankle clonus and a bilateral extensor response on plantar stimulation. The extent of the paralysis depends, of course, on the level of the lesion. If the tumor is above the cervical enlargement, the arms will be affected as well as the legs; if the lesion is above the lumbar enlargement, the legs alone will be affected; and if the lesion is below the second sacral segment, sphincter disturbance but no muscular paralysis will result. Often one side of the cord will be affected before the other and a partial Brown-Séquard syndrome may be found. This includes paralysis on one side of the body with a zone of hyperesthesia on the same side and cutaneous anesthesia on the opposite side.

The diagnosis depends upon the following points: (1) the history of a progressive course, (2) demonstration of a focal lesion of the cord with sensory level, (3) the absence of evidence of tuberculous spondylitis or of injury to the spine, and (4) the demonstration of a block in the spinal canal. The Froin syndrome (yellow spinal fluid containing an excess of protein which clots spontaneously)



is strong evidence of spinal compression. Spinal block may also be revealed by the Queckenstedt test, which is made by attaching a manometer to the lumbar puncture needle and compressing the jugular veins. If the canal is patent the increased intracranial pressure will be transmitted to the lumbar canal, but if no rise of pressure is seen in the manometer it may be assumed that the canal is blocked. The same results may be obtained by injecting lipiodol into the cisterna magna and determining by means of roentgenography whether it sinks all the way to the sacrum or whether it is arrested at the site of the lesion. These tests are of the utmost importance in the diagnosis of spinal cord tumor, and exploration is rarely justified in the absence of obstruction of the spinal canal.

The prognosis is bad. Few tumors of childhood can be completely removed. If operation is unsuccessful or too long delayed, the child usually dies of infection of the urinary tract, bed sores or some intercurrent disease. In case of an inoperable growth being found, radium or roentgenotherapy may be tried.

### NEUROFIBROMATOSIS

This condition, often called von Recklinghausen's disease,<sup>1</sup> includes the following manifestations: multiple soft tumors of the skin (*mollusca fibrosa*); multiple tumors situated on nerve trunks (*neurofibromata*); pigmentation of the skin, and sometimes mental deficiency. The symptoms may be noted at birth or soon afterwards, but usually make their appearance later in life. A common sequence is for excessive pigmentation alone to be manifested in childhood, the characteristic tumors making their appearance at puberty. The disease is often familial. Puberty and pregnancy seem to stimulate the growth of the tumors. They may remain stationary for years or may suddenly begin to grow actively without apparent cause. Sarcomatous changes may occur in apparently benign tumors. Various congenital defects are sometimes associated. The tumors may be confined to the subcutaneous tissues or may be absent from the surface of the body and present in great numbers inside the cranium, where they are attached to the nerves. The common acoustic tumor of adults is believed to be a solitary growth of the same nature.

Meningeal tumors are sometimes associated with intracranial neurofibromata, and in such cases the inner table may show numerous spicules of bone projecting into the cranium, each of which is capped by a meningeal growth. The spinal roots may be similarly affected and compression of the spinal cord result. The brachial and lumbosacral plexuses may be involved by multiple or plexiform tumors, but it is unusual for paralysis to result. In rare cases the walls of the intestines contain large or small tumors believed to spring from the intrinsic nerves. The pigmentation of the skin exists in two forms; in one there are large areas of coffee-colored pigment and in the other there are numerous small brown areas resembling freckles or flat pigmented naevi; both forms exist together. The cutaneous lesions exhibit considerable variety. Aside from typical *mollusca fibrosa* there may be, in association with subcutaneous plexiform neuromata, proliferation of the skin which hangs down in loose folds or flounces; these are usually found at the temples or in

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<sup>1</sup> This is not to be confused with the hyperparathyroid syndrome, *osteitis fibrosa cystica*.



the gluteal region (pachydermatoceles). In recent years several authors have called attention to bony changes associated with neurofibromatosis. The changes are attributed to a neurofibromatous growth of the periosteal nerves. There may result a localized bone tumor, at other times a diffuse hypertrophy of a bone, and in still other cases there may be cystic formations in the bone not unlike those of osteitis fibrosa cystica.

The exact origin of these tumors is still a matter of dispute and their histology is not always the same. The tumors of the central nervous system and retina often exhibit a mixed character, parts of them having the appearance of gliomata. The peripheral tumors contain predominantly connective tissue elements with a variable amount of nervous tissue. They are believed to originate from the sheath of Schwann or the endoneurium, and it is clear that their origin goes back to embryonic life.

The prognosis is bad if there is evidence of intraspinal or intracranial tumors, but the peripheral growths do not usually cause much disability. Single growths may be removed.

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## SECTION XVIII

### *DISEASES OF THE MUSCLES*

## CHAPTER CXVII

### DISEASES OF THE MUSCLES

#### CONGENITAL DEFECTS

It is not very unusual for certain muscles or parts of muscles to be absent from birth. The condition remains unchanged throughout life and hence is easily distinguished from progressive disease. The muscles most frequently affected are the pectorals, serratus anterior, trapezius and quadriceps femoris. The abdominal muscles may also be absent or incompletely formed, and in such cases there are often developmental defects in the bladder musculature or ureters. Symmetrical defects in the oculomotor and facial muscles are sometimes seen, and congenital ptosis of one or both eyelids is quite common. In some cases the motor nerves and nuclei are intact and the defect is apparently primary in the muscles; in other cases the corresponding motor cells are absent or deficient. In the latter case the term congenital nuclear aplasia is often applied.

#### TORTICOLLIS

Torticollis (wryneck) may be congenital or acquired.

*Congenital torticollis* may be defined as an abnormal position of the head due to fibrosis and shortening of the muscles of the neck. The deformity varies somewhat according to the muscles affected and the degree of shortening. In the simplest cases, where the sternomastoid alone is involved, the head is inclined to the affected side and rotated to the opposite side; the chin is raised and the ear approaches the clavicle. If the trapezius is involved there is less rotation of the head, but it is drawn to the affected side and somewhat backwards, the shoulder being raised and the spine curved. The muscle is more or less completely replaced by scar tissue; severe cases show a shortening of all the tissues on one side of the neck. No good explanation can be offered for congenital torticollis, and it is usual to attribute it to faulty position of the child *in utero*, or to compare it without further analysis to clubfoot and congenital dislocation of the hip. Torticollis has also been attributed to contracture resulting from hematoma of the sternomastoid caused by overstretching at birth, but it is probable that this is seldom the true cause. Very rarely congenital torticollis is the result of anomalies of one or more cervical vertebrae.

Mild cases may be treated by manipulation or by orthopedic apparatus and exercises. More severe cases require operation—resection of the contracted muscle



and its fibrous sheath with overcorrection of the position of the head in a plaster cast for six weeks. It is important to begin treatment early, for asymmetry of the face soon develops and grows more pronounced as the child grows older. This asymmetry is always more obvious when the position of the head is corrected, and this fact should be taken into consideration when planning operation in cases of long standing, although after correction there is a tendency for the asymmetry to diminish.

*Acquired torticollis* most commonly results from inflammation of the neck, as a complication of tonsillitis or pharyngitis. This form not infrequently follows scarlet fever, measles, or diphtheria. It is also seen with cervical adenitis, acute or tuberculous, and with cellulitis of the neck. Indeed, it may be the result of anything causing irritation of the trunk or branches of the spinal accessory nerve, either in the spinal canal or along the course of the nerve trunk or of any of its peripheral fibers. A cause which the physician should always have in mind is cervical Pott's disease; torticollis may be the earliest, and for several weeks sometimes almost the only objective symptom of this disease. Torticollis may also be due to nontuberculous arthritis. The cases associated with rheumatism, with focal infections and rheumatoid arthritis are of this class. They may be recognized from the associated symptoms in other parts of the body and by the fact that the neck is fixed by pain and muscle spasm; there is no permanent shortening and fibrosis of one or two muscles permitting free movement in other directions. In some cases torticollis is related to ocular imbalance, with weakness of some of the extra-ocular muscles; here it represents an attempt to superimpose the visual fields by tilting the head. Infrequent causes of torticollis are dislocations of the cervical spine and cervical rib. Torticollis may be a manifestation of hysteria; in such cases it may be persistent, but is more often intermittent or spasmodic in type.

The presence of constitutional symptoms depends on the cause of torticollis. In acquired cases the deformity generally develops gradually, several days or weeks elapsing before it is marked. Early in the disease the deformity can be partially or entirely overcome by passive force; but after a time this is impossible, owing to muscular shortening. Atrophy may take place in the affected muscles. In recent cases localized pain and tenderness are frequently present, and sometimes they are severe.

Recovery in many of the acute cases is complete in the course of a few days or weeks. In others, after the subsidence of the symptoms of local inflammation there may be no tendency to a diminution of the deformity. This, if untreated, may be permanent, owing to shortening of the muscles and fascia.

Treatment in the acquired cases should be directed toward the underlying cause. If the condition is of recent origin, some benefit may be obtained from hot applications, counterirritation and friction, unless the pain is too severe. Cases which have lasted a month usually require some orthopedic head-support, and those which have lasted six months or more are rarely cured without a surgical operation. This may be either a subcutaneous tenotomy or myotomy of the sternomastoid, or an open incision. An old case of torticollis is a serious matter and radical measures should be resorted to early in the disease. Spasmodic torticollis is a psychogenic condition and should be treated accordingly, although some surgeons



advise operation. Torticollis due to defective ocular balance should be treated by ophthalmologic methods.

### AMYOTONIA CONGENITA

This obscure disease was described by Oppenheim in 1900. It is not hereditary, but a few instances of its familial occurrence are recorded. The symptoms are usually noticed in the early months, sometimes very soon after birth. In some cases it has been observed even during pregnancy that fetal movements were less vigorous than usual. There is a general flaccid paralysis. That of the lower extremities is usually complete; but in the upper extremities feeble movements of the hands and arms may be present. The intercostal muscles and those of the neck are usually but not always involved. The diaphragm and all the muscles supplied by the cranial nerves escape. There is no ocular or facial paralysis.

In the well-marked cases the child lies completely helpless and motionless; the knee jerks are absent, but sensation is not affected. The electrical reactions are feeble or may even be absent. Owing to involvement of the intercostals the respiration is usually labored, panting and diaphragmatic in character. Secretions accumulate in the pharynx and air passages and choking attacks often occur. These may result in fatal asphyxia, or in aspiration pneumonia. The pulse is normal and regular. There are apparently no subjective symptoms. The infants are usually well nourished and may even be fat. In most of those who live for several months or years the intelligence is normal but microcephaly is sometimes associated; control over the sphincters is usually complete. Deformities of the chest are often produced as a consequence of the paralysis of the respiratory muscles.

Besides the marked form of the disease, to which the above description refers, it is now recognized that amyotonia may occur in all degrees of severity. In the mild form there may be only very great weakness and atony of the muscles. The ability to hold up the head or to walk may then be greatly delayed. These cases are often confounded with rickets; but the weakness in amyotonia is permanent. Owing to the greater involvement of some muscular groups, contractions may occur and may lead to confusion with poliomyelitis. The very mild forms of amyotonia may be readily overlooked.

The lesions are chiefly in the muscles. The descriptions of various observers differ somewhat in detail, but in general it may be said that some of the muscle fibers are hypertrophied, some are of normal size, but many are very small. The cross-striations are present; there is little replacement by fat and no considerable increase in connective tissue. The lesion is to be looked upon rather as a failure of development than as a degeneration. The nerves are usually normal and the brain also. The tracts of the cord are not affected, but in some instances a striking diminution in the number of cells of the anterior horns has been found. A delayed or retarded embryonic development of the muscles and motor cells of the anterior horns seems best to explain the pathological changes.

Many of the infants suffering from this disease die in the first year, most frequently from pneumonia, to which they are especially susceptible by reason of the condition of the respiratory muscles. The duration of the mild forms of the disease is indefinite. We have seen a few older children and young adults



with this form of the disease. In some cases a slight improvement has taken place, but no cures have been reported. The condition is not influenced by treatment. The disease usually either remains stationary or progresses very slowly, the child dying of some intercurrent disease.

Although the typical cases represent a distinct clinical group, it must be admitted that some cases are not readily classified. Transitional forms exist which connect this disease on the one hand with the muscular dystrophies and on the other with spinal muscular atrophy.

## MUSCULAR DYSTROPHIES

There are certain well-established facts in regard to the muscular dystrophies. The changes are primarily in the muscles. They are not dependent upon lesions of the nerves or the cord, even though secondary degenerations may be present in those structures. While isolated cases are here and there encountered, muscular dystrophies are family diseases. They affect boys rather more often than girls. What it is that determines the progressive wasting of the muscles is quite unknown. It appears to be an inherent weakness of the muscular system, an inability of the muscles to carry on the fight for existence. They fail to survive, just as various parts of the nervous system may fail and give rise to the progressive degenerative diseases of the nervous system.

The lesions of muscular dystrophy are essentially the same, no matter what the type. The individual muscle fibers waste. They become round instead of polygonal and eventually they disappear, leaving the sarcolemma sheath with more numerous nuclei. Certain of the fibers may actually hypertrophy to several times the size of the normal fiber, but this is only a temporary process. Eventually the hypertrophic fibers share in the general atrophy. Replacement of the muscle fibers by connective tissue occurs as the atrophy goes on, and coincident with the muscular atrophy a deposition of fat takes place in the muscle. This may largely compensate in amount for the atrophy of true muscular substance, so that the diminution in size of the whole muscle may be very gradual. This deposition of fat may even be excessive and thus lead to pseudohypertrophy. Upon the relative amounts of the muscular tissue, connective tissue and fat, depends the appearance of the muscles as a whole. They are lighter in color than normal, perhaps even yellow and soft. Eventually, the fat largely disappears and only firm, fibrous and contracted strands of connective tissue are left.

The *pseudohypertrophic type* is the most frequent and best-known variety of the muscular dystrophies. The symptoms as a rule come on early in childhood, nearly always before the tenth year, and generally between the second and seventh. The earlier symptoms relate to a general weakness of the lower extremities, which is accompanied by a marked increase in the size of certain muscular groups, usually those of the calves, but sometimes more of the thighs or the gluteal regions. The enlargement may affect almost any muscular group of the lower extremity. Children walk unsteadily and fall very easily. They have special difficulty in rising from the floor and in mounting stairs. The method of getting up from the floor in well-advanced cases is quite characteristic; the patient turns on his face and lifts his body until he touches the floor only with the hands and



feet; then he proceeds to "climb up himself" by putting first one hand upon the knee, and then the other, gradually moving his hands higher and higher up the thighs until the erect position is attained. This is seen in many of the cases, but not in all.

Most of these patients exhibit, while standing, a marked degree of lumbar lordosis, due to the weakness of the extensors of the hip and later of the muscles of the back. They stand with their shoulders far back. The patient may be so weak upon his legs that the slightest touch will cause him to fall, even with his apparently immense muscular development. The small muscles are generally weaker than those which are enlarged.

With the progress of the disease, the muscles of the arms and shoulders become involved. Some of these atrophy at once, others may exhibit pseudohypertrophy for a time. The infraspinatus is the most frequently enlarged, next the supraspinatus and the deltoid. The pectorals and latissimus dorsi are never enlarged but are generally markedly wasted. The weakness of the shoulder muscles produces the characteristic difficulty in picking children up by grasping them under the arms. They slip through the hands. The rhomboids and the levator anguli scapulae, the biceps and the triceps gradually are involved, and later in the disease there is such marked atrophy, with corresponding weakness, of all the affected groups that the patient may be unable to walk or even stand, and is absolutely helpless with the exception of the use of his hands. The knee jerk is at first normal, but gradually diminishes until it is finally lost. The ankle jerks persist much longer. The electrical reactions are normal until marked wasting occurs, when there is a lessened response to faradism and galvanism, but never the reaction of degeneration. There are no fibrillary contractions, and no sensory disturbances. The progress of the disease is generally slow, and sometimes irregular. It is often more rapid in early childhood, and slower after puberty. Many of these children, though apparently bright, are distinctly below the average for their ages.

The prognosis is grave, most patients dying in from five to ten years. Death seldom results from the disease itself, but rather from some intercurrent disease, especially of the lungs. Nothing can be done to stay the course of muscular dystrophy. The diagnosis is generally easy from the selective weakness and atrophy of the proximal muscle groups. The presence of pseudohypertrophy is conclusive.

A *juvenile form* is also described in which the symptoms appear between the tenth and sixteenth years, and also a form in which the facial muscles are among the first to be involved. These are all essentially the same condition and do not warrant separate descriptions.

### CONGENITAL MYOTONIA

This rare disease, first described by Thomsen, is usually congenital. It may occur in several members of the same family, and is almost always hereditary. The characteristic symptom is a peculiar rigidity of the muscles, which is observed when they are first brought into action after repose. This rigidity usually continues but a few moments. It may recur when voluntary movements are again attempted.



If, however, muscular effort is persisted in, it soon passes off. It is increased by apprehension, excitement, or cold, and under observation. The legs are most frequently affected, the condition being often noticed when the patient starts to walk; any of the voluntary muscles, however, may be involved, even the tongue. It may be greater upon one side of the body than upon the other. The tendon reflexes are not increased, but direct mechanical stimulation of the muscles produces a marked and very prolonged contraction. Electrical stimulation of the nerves causes normal or diminished contractions; that of the muscles directly, either with the faradic or galvanic current, causes a contraction that remains for from ten to twenty seconds. The disease may be noticed very early in life and it generally increases in severity about the time of puberty. Thereafter it remains stationary, or nearly so. It never causes death but is incurable, although the symptoms may be improved somewhat by active muscular exercise. Personality defects and even psychoses sometimes occur in affected families.

The muscle fibers are increased in size and the nuclei much increased in number. There are no evidences of degeneration, but in the sarcoplasm may be seen a large number of small, round, colorless or yellowish dots that seem to indicate actual disease of this substance. Something can be accomplished by massage and muscular exercise to diminish the tendency to muscular rigidity, but nothing approaching a normal condition can be brought about.

### PERIODIC FAMILIAL PARALYSIS

This disease is characterized by recurrent attacks of muscular weakness or paralysis which may be so complete as to involve all but the respiratory muscles and those supplied by the cranial nerves. It occurs in several members of one family and is transmitted from one generation to the next, affecting males and females indiscriminately. The attacks may occur at any time but are perhaps most common at night. The paralysis begins in the proximal muscles and slowly extends to the distal segments. It may last several hours or a whole day, passing off as gradually as it came. The tendon reflexes are abolished and even muscular irritability is lost, so that the muscles do not respond to electrical stimuli or direct percussion. No sensory changes are found and consciousness is not affected. Severe attacks may cause profuse sweating and signs of cardiac weakness. The cardiac dulness may be increased. These attacks may persist throughout life and may alternate with migrainoid headaches. In some cases the shoulder-girdle and pelvic-girdle muscles are underdeveloped or wasted and a suspicion of muscular dystrophy may be entertained. Death may occur during very severe attacks from cardiac failure or respiratory weakness.

Numerous metabolic studies have been made which have given conflicting results, and the underlying physiological disturbance is unknown. Overeating and fatigue are usually given as precipitating factors. The prognosis is poor and more than half of the cases result fatally, but improvement and even more or less recovery is possible. The diagnosis is not always easy and the condition may be confused with polyneuritis, arthritis, and trichinosis in the early stages and with scleroderma in the later stages. There may be intermittent muscular weakness during the periods of exacerbation of dermatomyositis; the association of derma-



titis with swelling and tenderness of the muscles should suggest this diagnosis, which may then be verified by the removal of a bit of muscle for histological study.

Postmortem examination reveals pale red or yellowish muscles, which are firm but rather fragile. Histologically the muscle fibers are found to be undergoing hyaline, waxy or more rarely fatty degeneration. Numerous small areas of lymphocytic infiltration are found, especially in the intermuscular septa and about the small blood vessels. There is always great proliferation of the interstitial connective tissue. A type in which there are many small hemorrhages into and between the muscles is also described, and which is sometimes associated with purpura. The subcutaneous fat is replaced with dense connective tissue infiltrated with yellow serum. Cultures are usually negative and the etiology is unknown. The heart and joints are not affected but the spleen may be enlarged.

### POLYMYOSITIS

**Myositis Ossificans.**—This is a rare condition which begins in the first decade and advances by acute exacerbations throughout life. The etiology is quite unknown. The first symptoms are fever and soft swellings in the muscles, which are tender for a short time. The swellings then recede and smaller firmer areas remain which later ossify. The bone is first laid down in the connective tissue of the muscle sheath and intermuscular septa, but sooner or later the bony deposits become attached to the skeleton and ultimately complete immobilization results. The muscles of the neck and back are usually first affected but in the later stages the process is generalized. In some cases there is congenital shortening of the great toes, which suggests that an inherent defect of metabolism may be to blame. The prognosis is bad and no treatment is known. Recently Frölich has claimed success with a ketogenic diet. This condition must be distinguished from localized bone formation in the muscles as a result of trauma and from subcutaneous deposits of calcium.

**Myositis Fibrosa.**—This disease also starts early in life and progresses slowly and steadily. The muscles become indurated and lose their elasticity so that movement eventually become impossible. The sternomastoids and muscles of the legs, neck, chest and back are among those first affected. At autopsy the muscles are found to have degenerated and to be replaced by connective tissue.

**Dermatomyositis.**—This condition is a rare one but not so excessively rare as the two types mentioned above. It may be defined as an inflammatory process affecting the muscles and subcutaneous tissues and associated with dermatitis. It may occur at any age. The onset is usually acute and accompanied by pain and fever. The muscles are swollen and tender at first but later grow indurated and inelastic. While in a few cases the course is steadily progressive, the majority show repeated exacerbations marked by periods of high fever, eosinophilia, extreme muscular tenderness, leading even to pseudoparalysis, and loss of reflexes; within a week or so these symptoms may largely subside, only to reappear after an interval. The skin lesions are not characteristic but erythema is common. Urticaria, roseola and erythema nodosum are also described. The dermatitis often appears first above the eyelids and on the chest. It is associated with edema of the subcutaneous tissues and may be followed by pigmentation.



In the last stages the induration of the skin and subcutaneous tissues is so marked that the picture closely resembles scleroderma. The muscles eventually become severely atrophied and show more or less loss of electrical reactions. Contractures are common.

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## SECTION XIX

### *THE SPECIFIC INFECTIOUS DISEASES*

Infectious diseases differ greatly in the ease with which they are communicated and in the method of spread. The methods of control and the isolation technic will therefore vary. Below are given the general principles and some details which are applicable to the more contagious diseases.

The isolation of a contagious patient has a twofold object—the prevention of infection in others and the protection of the patient himself from complicating infections. Every contagious patient should be individually isolated. It is well to define accurately a “contaminated zone” in which the patient is kept. This may be a room, a cubicle or a portion of a room screened off. Gowns, masks, and washing facilities should be available at the entrance of the contaminated area, and it is a wise precaution to insist that those who come inside wash their hands thoroughly both before and after contact with the patient. Stethoscopes and other instruments used by the physician should be washed or wiped in some antiseptic solution. Any object coming in contact with the patient or infectious material from the patient must be cleaned or destroyed on removal from the contaminated zone. The number of persons who come in contact with the patient should be reduced to a minimum.

Provision must be made for the disinfection of linen, diapers, dishes, and any object the patient touches, before they can come in contact with other members of a household. A boiler containing lysol may be kept outside the contaminated area for soiled linen. If there is much sputum it should be received in paper cups, which should be burned, or in vessels containing 5 per cent solution of carbolic acid. All discharges from the mouth, nose, eyes and ears should be collected on old linen, cheese cloth or absorbent cotton, thrown into paper bags and burned. Special disinfection of discharges from the bowels is not needed in the diseases treated in this section, except in the care of typhoid cases. All remnants of food should be burned. All dishes, knives, forks, spoons, etc., should be boiled. At the termination of quarantine the patient should receive a thorough bath, including the hair, with soap and water, and entirely clean clothing put on in an adjoining room.

Subsequent to the illness the room should receive thorough cleaning. Floors, woodwork and furniture should be scrubbed with soap and water. Toys and books used in the sick room should be destroyed. The mattress and blankets should be disinfected by steam, if possible; if not, they should be exposed for one or two days to sunlight and beaten in the open air, to remove all dust. All washable bedding should be treated as heretofore mentioned. Not only the sick room but the adjoining room much used by attendants should receive special cleaning. Fumigation is unnecessary if the above directions have been thoroughly carried out. Its value has always been problematical, and it has been generally abandoned by health authorities. Its efficacy is in no way to be compared to the special cleanliness heretofore emphasized.



## CHAPTER CXVIII

### SCARLET FEVER

Scarlet fever (scarlatina) is an acute, contagious, self-limited disease, usually ushered in by vomiting, fever, and sore throat, characterized by an erythematous rash appearing first on the neck and spreading rapidly over the trunk and extremities, and followed by desquamation. The period of incubation is generally from two to five days; that of invasion from twelve to twenty-four hours, and that of desquamation from three to six weeks. It is frequently complicated by otitis, mastoiditis, suppurative adenitis and nephritis.

**Etiology.**—The disease is caused by a group of beta-hemolytic streptococci, the *Streptococcus scarlatinae*, which possess in common the ability to produce a soluble toxin. It is surprising that the recognition of the part that streptococci play was delayed so long, for Moser produced a therapeutically effective serum in 1902, utilizing streptococci from scarlet fever patients, and in 1905 and 1907 the Russians Savchenko and Gabritschewsky reported important observations. They demonstrated that the streptococci produced toxin, that an injection of a bouillon suspension of dead bacteria produced symptoms singularly like scarlet fever, and that children could be protected against the disease by prophylactic vaccination. None the less, until recent years streptococci were generally looked upon as important factors in the disease but not the primary one. Since 1920 a mass of facts have been offered by Dochez, G. F. and G. H. Dick, and others that compel a different opinion. Scarlet fever has been produced in volunteers by painting their throats with scarlatinal streptococci. The same organisms have been found with regularity in all cases of scarlet fever, no matter what the origin, whether from the throat, from wounds or from lochial discharges. The toxin produced by the growth of these organisms will regularly evoke a reaction (Dick test) in the skin of susceptible persons. The serum of convalescents contains an antitoxin which neutralizes this toxin so that a negative Dick test is obtained. An antitoxic serum has been produced from animals that has a pronounced effect against scarlet fever when injected early in its course. When human serum containing antitoxin is injected into the skin of a scarlet fever patient a local blanching of the eruption occurs (the Schultz-Charlton extinction reaction). The proof that scarlatinal streptococci represent the primary etiological factor appears to be conclusive, although a few authorities<sup>1</sup> still hesitate to accept this view.

Scarlatinal toxin is not altogether analogous to diphtheria toxin. It is relatively thermostabile and relatively innocuous to laboratory animals. Apparently it is also innocuous to the newly born infant, who gives a negative Dick reaction although his blood contains no antitoxin.

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<sup>1</sup> Cf. Wadsworth, *J. Am. M. Ass.* 1932, 99: 204. Also MacCallum, *A Textbook of Pathology*, 5th ed., Saunders, Philadelphia, 1932.



According to Stevens and Dochez, Cooke, and others, allergy is necessary for the toxin to produce clinical manifestations; it is harmless unless the individual has become sensitized. The young infant is apparently sensitized by his first beta-hemolytic streptococcus infection; after this he reacts positively to the Dick test and with his next infection he may exhibit scarlet fever. He presumably remains sensitive thereafter, but this cannot be demonstrated because antitoxin has then developed, and the offending substance is neutralized as soon as it is introduced.

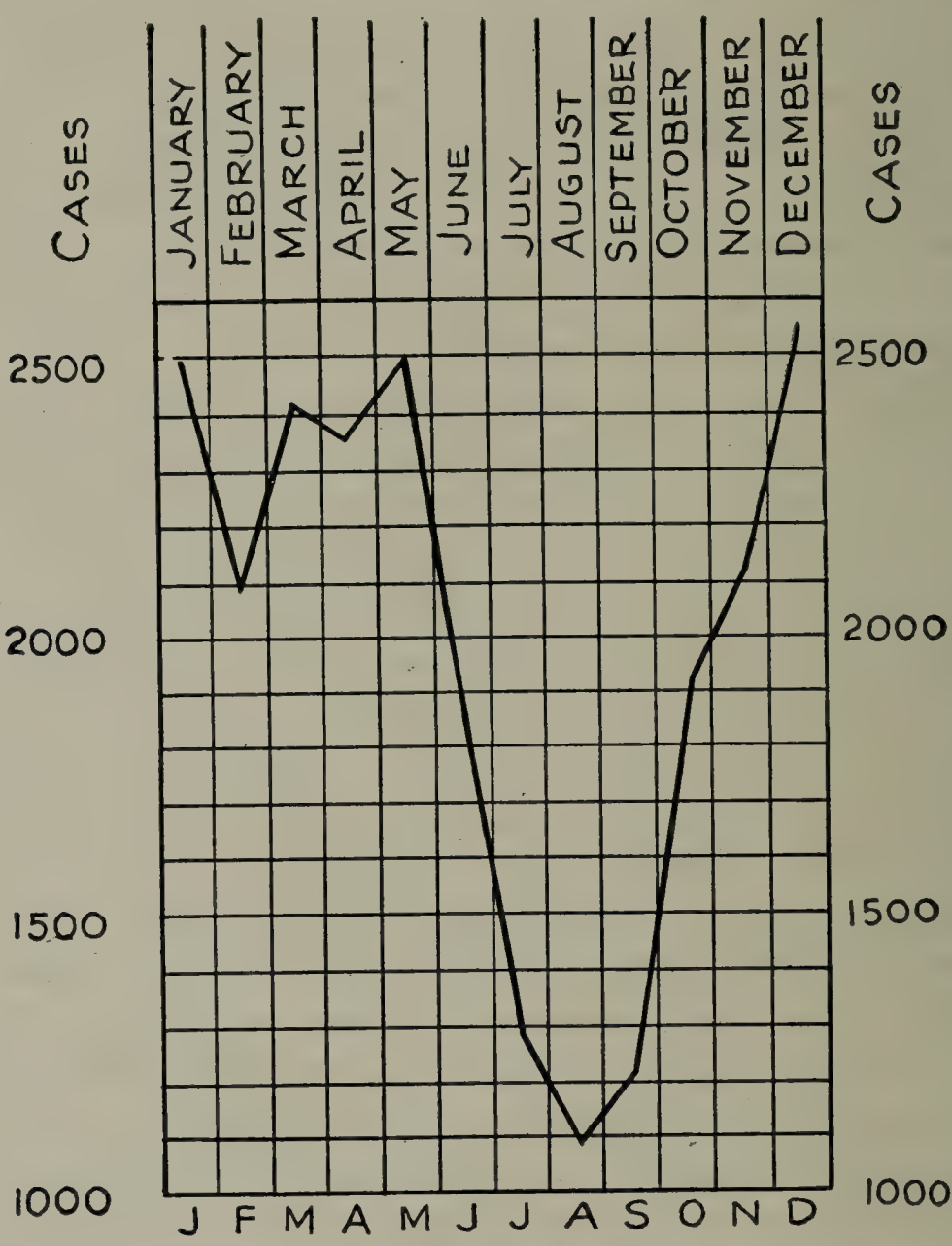


FIG. 137.—SEASONAL INCIDENCE OF SCARLET FEVER.

Cases of scarlet fever in Boston, by months, reported to the Board of Health from 1890 to 1904. (From McCollom and Place.)

It was once thought that scarlet fever conferred a permanent immunity, and it is a fact that clinical scarlet fever *with a rash* rarely occurs twice. However, it is now well known that infection with scarlatinal streptococci can and frequently does occur without a rash (*scarlatina sine eruptione*), and that an attack of scarlet fever does not protect against infection with these organisms. With subsequent attacks there may occur all the manifestations of scarlet fever except the rash, including its complications. The immunity following an attack of scarlet fever is therefore more apparent than real; it is an immunity to the toxic manifestations of the infection—perhaps to the rash alone.

Many older individuals are seen whose blood contains antitoxin, but who give no history of having had scarlet fever. It is likely that they have suffered from



abortive unrecognized attacks. Occasionally individuals are met with who after typical scarlet fever exhibit no antitoxin in their blood and remain Dick-positive. These are the rare persons who may later develop second attacks of typical scarlet fever.

**Susceptibility.**—The Dick test is a good index of susceptibility to the disease in its typical form. Of 200 infants under six weeks of age tested by Cooke only 1 per cent were Dick-positive to the injection of two skin-test-doses of toxin. The negative reaction in these cases was shown to be independent of the presence of any toxin-neutralizing substance in the infant's circulating blood. The proportion of positive reactors rises rapidly in the first few months of life and at the age of one year includes over 95 per cent of infants in some urban communities. From this age onward the per cent of reactors decreases, more rapidly in congested areas than in rural districts. This decrease is associated with the appearance of antitoxin in the blood.

The susceptibility of children to scarlatina is much less than to that of measles; still, it is much greater than that of adults. Billington records observations made in 26 families living in tenements where little or no attempt at isolation was made. In these families there occurred 43 cases of scarlet fever; but 47 other children, although unprotected by previous attacks and constantly exposed, did not contract the disease.

Johannessen reports that of 185 children under fifteen years who were exposed, 28 per cent contracted the disease; while of 314 adults, only 5 per cent contracted the disease. Fully half the cases occur in children between the third and eighth years, and 90 per cent in those under fifteen years. The seasonal incidence is well shown in the accompanying chart (Fig. 137).

**Incubation.**—Of 113 cases in which the period of incubation could be accurately determined, it was as follows:

<i>Cases</i>		<i>Cases</i>	
Twenty-four hours or less.....	6	Eight days .....	2
Two days .....	15	Nine days .....	5
Three days .....	28	Eleven days .....	1
Four days .....	25	Fourteen days .....	1
Five days .....	6	Twenty-one days .....	1
Six days .....	15		—
Seven days .....	8	TOTAL .....	113

Thus in 87 per cent of these cases it was between two and six days, and in 66 per cent between two and four days. It seems likely that the longer incubation periods reported may not represent the interval from the last actual contact. Speaking generally, if, after exposure, a week passes without symptoms, the chances of infection are very small. A short incubation is more frequently seen in severe than in mild cases.

**Mode of Infection.**—The chief source of infection is the patient himself. It is to the mild and unrecognized cases which act as carriers that the spread of the disease is frequently due. Infection is conveyed chiefly by direct or droplet transfer of discharges from the affected mucous membranes. Occasionally it is transferred from a suppurating focus in the patient to the oral mucous membrane of a sus-



ceptible individual or to an open wound; the latter is the common mode of conveyance in surgical or obstetrical scarlet fever. In uncomplicated cases the organism is found only in the respiratory tract, but in those with blood stream invasion it may localize anywhere. There is no reason for believing that scarlet fever can be conveyed by the scales during desquamation, or by the excreta of the patient—the urine, feces and perspiration. Infection can apparently take place from the carpets or furniture of the sick room, from toys or books, or from clothing. Cats, dogs and other domestic animals in rare instances have been thought to convey the disease. Scarlet fever is sometimes spread by milk. The simultaneous occurrence of a considerable number of cases in a community should lead one to suspect the milk supply.

Numerous instances are on record of transmission of the disease by carriers. Nurses and physicians in particular may convey the disease by contact, even though they do not carry the organisms in their throat. Such infection occurs rarely unless there has been very direct contact with the patient, and when the interval before seeing the second child is short. All sources of infection except contact with a person suffering from the disease are relatively infrequent.

**Duration of the Infective Period.**—There is no evidence to show that the disease is communicable during the period of incubation. It is slightly contagious from the beginning of invasion, before the rash appears. Infection appears to be most active at the height of the febrile period, which is from the third to the fifth day.

In simple cases, the average duration of the contagious period may be placed at about four weeks; in those complicated by otitis media, gland abscesses, or other sources of purulent discharge, isolation must be prolonged until these have cleared. The infectious nature of these discharges is well established. One case is recorded in which scarlatina was communicated through a purulent nasal discharge after eleven weeks; another where the opening of a postscarlatinal empyema in a surgical ward was followed by an outbreak of scarlet fever. Even without such purulent discharges, the organism may at times persist in the throat for many months. Infection has been caused by such cases as late as fourteen weeks. It is impossible to say that at any specified time absolute safety exists. Probably the only practicable method at present available for the detection of carriers is the recovery of toxin-producing beta-hemolytic streptococci from the throat.

**Pathology.**—The only characteristic lesions of scarlatina are those of the skin and the mucous membranes of the mouth and throat. The skin is the seat of an acute dermatitis of variable depth and intensity. There is first acute hyperemia, followed by an exudation of serum and cells, chiefly polymorphonuclear, into the corium, especially about the blood vessels and hair follicles. There results a death of the epidermis which is thrown off in the desquamation. The mucous membrane of the mouth, tongue, and throat is the seat of a catarrhal, membranous, or gangrenous inflammation which rarely invades the larynx, but very frequently the middle ear and nose. The entire esophagus is often the seat of an intense congestion. From the ear the infection may extend to the mastoid cells, the meninges, or the brain, and from the nose to the accessory sinuses, particularly the antrum.



All the lymph nodes about the neck may be involved, the infection may terminate in suppuration. The cellular tissue of this neighborhood may also become infiltrated, this being followed sometimes by suppuration and occasionally by gangrene.

The most constant change throughout the body is hyperplasia of the lymphoid tissue, which is seen everywhere. The other lesions are degenerations due to the toxin alone, or in conjunction with the various forms of secondary infection, or to the latter alone. The most important are: myocarditis; areas of focal necrosis in the liver; proliferation of the cells of the malpighian bodies of the spleen; broncho-pneumonia, gangrene, or abscess of the lung; pleurisy, which is often purulent; endocarditis, pericarditis; abscess in the cellular tissue and inflammation of the joints. The lesions of the kidney vary according to the stage of the disease. Early in scarlet fever only degeneration is found. Later there may be an interstitial nephritis with a very striking infiltration of the kidney with wandering cells, chiefly plasma cells and lymphocytes; the essential structures of the kidney are unaffected and it is doubtful if the process becomes chronic or causes more disturbance than a transitory albuminuria. The most characteristic lesion is a glomerular nephritis, which develops in the third or fourth week. The glomeruli are extensively altered. There are hemorrhages within the capsule, an accumulation of cells that are produced by a proliferation of the capsular epithelium and of the endothelial cells of the tuft, and hyaline changes in the glomeruli. The cells of the convoluted tubules participate also in the process, undergoing destruction and desquamation. The interstitial tissue may or may not be infiltrated with cells. This lesion is usually entirely recovered from, but it may be the beginning of a chronic process. Ordinarily there is a return to normal of the least injured portions, which may so far exceed in amount the parts permanently injured that the kidneys are able to perform their functions satisfactorily throughout the rest of life. Although the glomerular nephritis following scarlet fever has usually been regarded as a toxic manifestation, it is a significant fact that it ordinarily makes its appearance only after antitoxin has appeared in the blood.

**Symptoms.**—*Invasion.*—As a rule, the invasion of scarlet fever is abrupt, the symptoms at the onset usually being directly in proportion to the severity of the attack. In the majority of cases there is vomiting, a rapid rise in temperature, and soreness of the throat. Often the vomiting is repeated; it is frequent, forcible, and without nausea. In severe cases the rise in temperature is very rapid, to 104° or 105° F.; in the mildest cases it may not be above 101° F. A child may complain of soreness of the throat, or the throat symptoms may be entirely objective. In mild cases the throat shows only a very moderate congestion. In most severe cases there is a uniform erythematous blush covering the pharynx, tonsils, and fauces, but on the hard palate it appears as minute red points. Occasionally membranous patches are seen upon the tonsils the first day, but generally not before the third or fourth day. Severe cases are sometimes ushered in by convulsions, especially in very young children. There is general prostration, which is directly proportionate to the height of the fever.

*Eruption.*—This usually appears from twelve to thirty-six hours after the first symptoms of invasion; exceptionally, not until the third or even the fifth day. A



later appearance than this is somewhat doubtful, for the rash not infrequently recedes and reappears, having been overlooked in the first instance. In 108 cases tabulated the duration of the rash was as follows:

	Cases
Two days or less .....	5
Three to seven days .....	81
Eight to eleven days .....	16
Over eleven days .....	4
Recurring .....	2

These figures are confirmed by the observations of most writers, that the rash lasts from three to seven days. The full development of the rash is generally seen in from twelve to twenty-four hours from its first appearance, and not infrequently the whole body is covered in the course of four or five hours. Its first appearance is almost invariably upon the neck and chest. Its color is red rather than scarlet, and on close inspection it is seen to be made up of very minute points upon a reddish background, giving the appearance of a uniform blush; or the background may be wanting and only the punctate eruption show. These points are the papillae of the skin and hair follicles. In many cases the rash is partly hemorrhagic and fails to blanch completely on pressure; streaks of petechiae are commonly found along the folds of skin in the bend of the elbow, in the axillae and groins, and in the neck. There may be petechiae in regions where the eruption is particularly brilliant. Application of a tourniquet will usually produce a crop of petechiae (Rumpel-Leede phenomenon), but this is not pathognomonic of scarlet fever. The rash usually covers the entire body except the face and scalp. Even in cases with intense eruption the central part of the face usually escapes; there is often pallor about the mouth and nose.

The appearance of the eruption in dark-skinned races is much modified and often difficult of recognition. In the Negro the palms and soles may be the only places where it can be distinguished. Here may be seen a bright-red blush or a fine papular eruption. Palpable thickening of the skin and miliary vesicles in the axillae and over the lower abdomen may assist in the diagnosis.

Variations in the eruption are frequent and puzzling. They occur especially in the very mild and in the most severe cases. When the rash is faint or scanty it is usually most marked in the groins and axillae, or over the buttocks and back and inner surface of the thighs; it may last only one day, and is sometimes so slight as to escape notice altogether. The eruption may be absent in some very mild cases, in certain others where the throat symptoms are severe, and in malignant cases. *Scarlatina sine eruptione* may occur in young infants who are not yet sensitive to the specific toxin, and in older individuals who have acquired antitoxin. In the very severe cases many irregularities are seen, both as to the time of the appearance of the eruption and its character. Sometimes it occurs in large, irregular patches; again, it is macular, closely resembling the rash of measles or of rubella. Not infrequently an eruption of fine vesicles is seen, especially on the chest, axillae and abdomen. It occurs both in mild and severe cases. The fluid may contain so many leukocytes as to be purulent. A well-developed bright rash indicates a vigorous circulation; a sudden recession of the rash is a sign of circulatory failure. Often a



rash which is faint and doubtful in character may be brought out fully by a hot bath.

With the eruption at its height, itching or burning may be complained of, and in severe cases there is considerable swelling, noticeable chiefly in the hands and face. As the eruption subsides the hair follicles may remain prominent for a few days and give the skin a harsh, sandy texture.

*Enanthem.*—At the onset the throat usually shows a uniform congestion involving the pharynx, tonsils and fauces. By the end of the first or second day, and usually with the appearance of the skin eruption, fine points of submucous hemorrhage frequently appear on the palate, sometimes extending in an arch along the margin of the hard and soft palates. In most cases the tonsils go through the cycle of changes of a moderately severe attack of acute follicular tonsillitis; in patients whose tonsils have been removed, the picture is less striking, being that of pharyngitis with petechiae. The pharynx and tonsils may show anything from a fine punctate blush to the extensive membranous inflammations that are occasionally met with.

The changes in the tongue are often very typical and may be of assistance in diagnosis. On the first day there is a heavy coating, which some twenty-four hours later has begun to clear at the tip and margins; the swollen papillae show through as bright red points. The clearing gradually proceeds backwards. When the coating has disappeared the tongue is left raw and glistening, studded with swollen papillae which give it the familiar “strawberry” appearance.

*Desquamation.*—This begins shortly after the rash has faded, usually about the eighth day, and is even more characteristic of the disease than is the rash. It is usually first seen upon the neck and chest, where it appears as fine flakes. Depending upon the intensity of the eruption the desquamation takes place in the form of fine flakes or larger pieces, sometimes an inch or more in diameter. The desquamation of the trunk is completed in from one to three weeks. If baths and inunctions are being used, it may be scarcely perceptible. It continues longest where the epidermis is thickest—upon the hands and feet—and here it lasts from four to seven weeks, and not infrequently eight weeks. The appearance of the fingers and toes during desquamation is characteristic. The finger tips usually peel first, and the new epidermis is pink and fresh-looking, while that which has not yet separated is of a dull gray color and loosened at the margin. Occasionally the epidermis of a considerable part of a finger may be loosened at once, so that a partial cast is thrown off like the finger of a glove. More often there is only a splitting and loosening of the skin next to the tip of the nails. Sometimes the patient comes under observation for the first time during desquamation, the history of the early symptoms being doubtful or absent. Such desquamation as has been described, occurring both upon the hands and feet, may be regarded as conclusive evidence of scarlet fever.

*Mild Cases.*—The symptoms may be so slight as to be entirely overlooked, nothing being noticed until desquamation occurs. Usually, however, there is a rather abrupt invasion, with vomiting and a temperature from 100° to 103° F. The tonsils and pharynx are congested, while the palate shows a punctate redness somewhat like the cutaneous eruption. The papillae of the tip and borders of the



tongue are enlarged. Nearly always within twenty-four hours the rash makes its appearance, generally first upon the neck and chest. Very often it is not seen upon the face, but is abundant on the rest of the body. The rash has usually quite disappeared by the fourth or fifth day. There is very little prostration, the child often being with difficulty kept in bed.

The highest temperature is coincident with the full eruption, and is usually seen during the first thirty-six hours of the disease. It gradually falls to normal by the third or fourth day. Some examples are shown in Figure 138. In the mildest cases the temperature may never be above 100° F.

Desquamation is often faint over the body, but is usually unmistakable over the hands and feet. On the trunk it is always most marked where the eruption has been most intense.

The mild cases are usually uncomplicated, but the possibility of otitis and even of late nephritis should always be kept in mind, as these may occur even with the

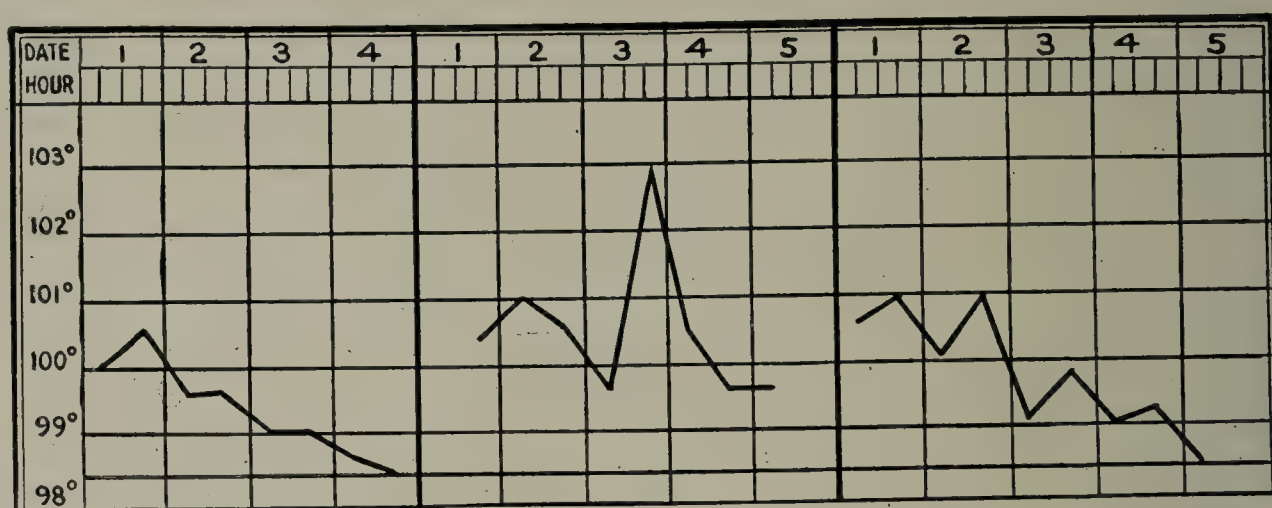


FIG. 138.—MILD SCARLET FEVER.

Three cases occurring successively in the same family. Diagnosis not made until the third case developed, at which time the first one was found to be desquamating in a typical manner.

mildest attacks. The difficulties in diagnosis in mild attacks of scarlet fever are often great. It should be remembered that these cases are just as contagious as severe ones, and that from a mild attack a severe one is often contracted. In dispensaries, patients desquamating from scarlet fever are sometimes seen who had been attending school regularly up to the time when they were brought for treatment of nephritis.

*Cases of Moderate Severity.*—The onset is sudden, with vomiting which is usually repeated, rarely with convulsions. The temperature rises rapidly, and by the end of the first twenty-four hours has reached 104° or 105° F. The rash generally appears within the first twenty-four hours, and its intensity is usually in direct proportion to the severity of the attack. Appearing first upon the neck or chest, it extends rapidly, covering the entire trunk and extremities, often in a few hours. It is generally typical in appearance, being made up of minute points, but giving the appearance of a uniform blush which has been compared to a boiled lobster. After the fourth or fifth day the rash fades quite rapidly, and disappears by the sixth or seventh day.

The throat resembles that of the mild form, except that the redness is more intense and there is slight swelling of the tonsils, fauces, and uvula, and often



pain upon swallowing. Occasionally small yellowish patches are seen upon the tonsils by the second or third day, but these can be wiped off and are not distinctly membranous. There is usually a moderate discharge of a seropurulent character from the nose due to paranasal sinusitis. The lymph nodes at the angle of the jaw are swollen and quite tender. The tongue may be coated in the center and show bright red points at its borders and tip, or it may be quite red and show everywhere the prominent papillae—the “strawberry tongue”; while not exclusively seen in scarlatina, this is of considerable diagnostic value. It is rarely seen before the third day, and may continue several days or even weeks.

The temperature usually reaches the maximum by the second day, and falls gradually, but even in uncomplicated cases the fever often lasts from ten to fourteen days. The pulse in the early part of the disease is rapid, its frequency being usually out of proportion to the height of the temperature. There is much prostration, frequently followed by quite a marked degree of anemia.

This form of the disease rarely proves fatal apart from complications.

*Severe Cases.*—The severe type of scarlet fever usually declares itself from the beginning. The incubation is short, and the full rash may be seen within a few hours after the initial symptoms. It is usually intense and covers the entire body, even including the face. In other cases the eruption is delayed, often scanty, and may disappear in a few hours. The disease assumes one of two fairly distinct types; one is characterized by the severity of the general toxemia, the other by the predominance of the throat symptoms. In the first group the toxemia is shown by the height of the temperature, the severity of the nervous symptoms, and the profound circulatory depression. The temperature quickly rises often to 105° or 106° F., and usually remains steadily high until the death of the patient. The nervous symptoms are great prostration and delirium, which is sometimes active, but more often low and muttering. The pulse is very rapid, 160 to 180 being not uncommon; it is weak, compressible, often irregular, and the muscular sounds of the heart are feeble. The urine is scanty and almost invariably albuminous, with perhaps a few red blood cells. Hemorrhages from the mouth, the nose, or other mucous membranes are occasionally seen. The duration of the disease in this form is generally from five to seven days. Exceptionally the symptoms develop with greater intensity, and death follows in three or four days. A shorter duration than this, the so-called malignant scarlet fever, is rare.

In the second group with predominant throat symptoms, the first three or four days may show nothing more than cases of the moderate type. Membranous patches then appear upon the tonsils and spread to the soft palate, uvula, and pharynx,

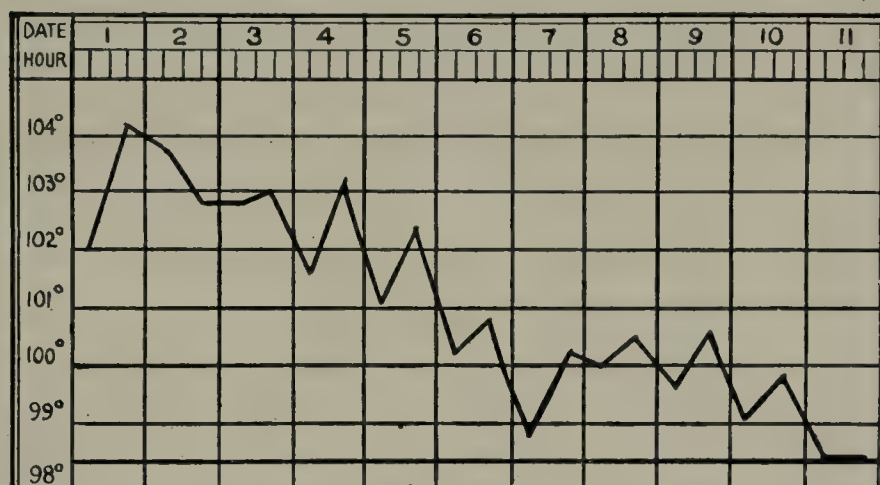


FIG. 139.—TYPICAL TEMPERATURE CURVE OF UNCOMPLICATED SCARLET FEVER OF MODERATE SEVERITY IN GIRL THREE YEARS OLD.



sometimes to the nose and through the eustachian tube to the ear, rarely involving the larynx. The mucous membrane of the mouth is intensely congested, and often partly covered by membrane; there are sordes on the lips and teeth, and there may be superficial ulcers, which bleed readily. The glands of the neck swell rapidly, often to a great size, and the cellular tissue about them is infiltrated. In extreme

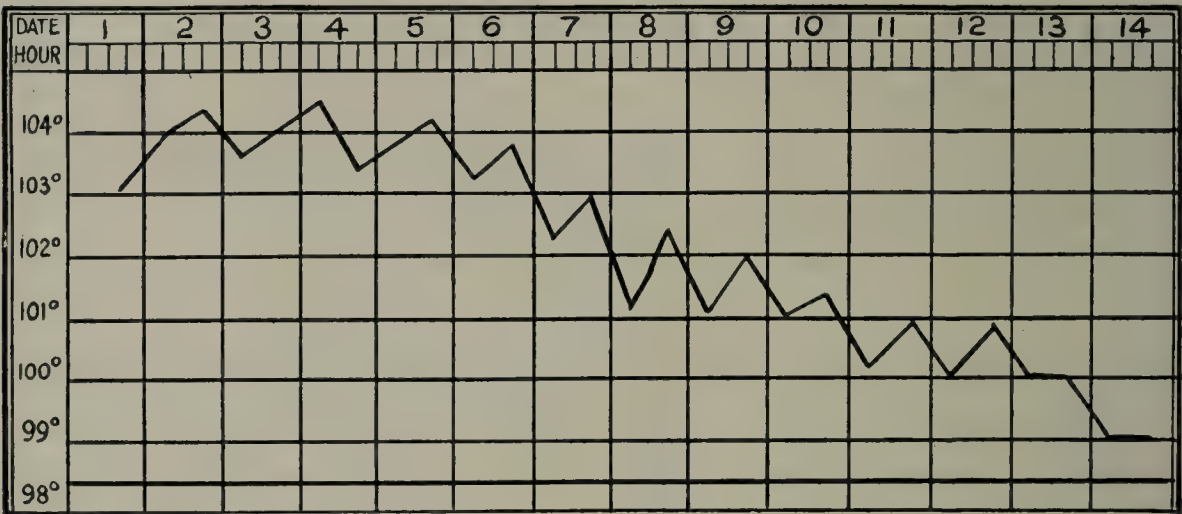


FIG. 140.—TYPICAL TEMPERATURE CURVE OF SEVERE SCARLET FEVER ENDING IN RECOVERY. Prolonged course due to severe throat symptoms lasting from second to sixth day; otherwise uncomplicated; boy twelve years old.

cases the external swelling extends like a collar from ear to ear, resembling the “bull neck” of diphtheria. The head is thrown back to relieve the dyspnea which the pressure from this swelling occasions. There is an abundant discharge from the nose and mouth; the breath is very offensive. Local symptoms of this type are accompanied by constitutional symptoms of great severity; often there is a streptococcus septicemia. The temperature is steadily high, usually between 103° and 105° F., for about a week, after which in cases ending in recovery it slowly falls

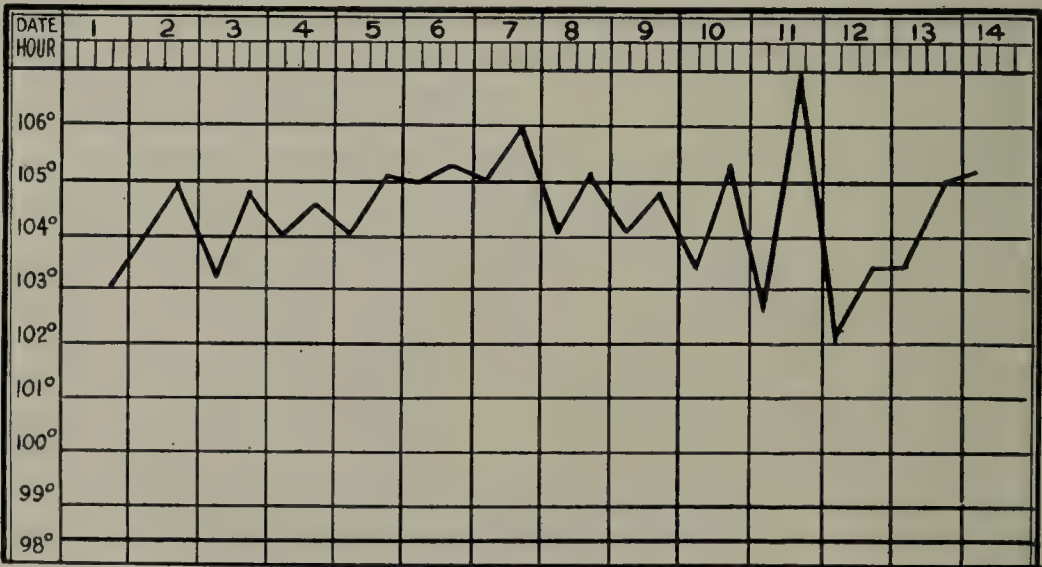


FIG. 141.—SEVERE SCARLET FEVER, SEPTIC TYPE; DEATH ON FOURTEENTH DAY. Intense angina, otitis, nephritis, necrotic inflammation of cervical lymph glands; girl seven years old.

unless complications develop; but even in uncomplicated cases the fever sometimes continues for three weeks. In fatal cases the temperature may be steadily high till death (Fig. 141), or it may fluctuate widely. The pulse is rapid, weak, and irregular. There is low delirium or apathy, and sometimes all the symptoms of the typhoid condition.



Signs of a bronchopneumonia may be found, and by the end of the first week or early in the second, acute otitis often develops. The urine is rarely free from albumin, but the amount present is not usually great; there may be hyaline and epithelial casts, and sometimes blood. In some cases the throat symptoms predominate; in others, those of general sepsis, but more frequently the two are combined and are directly proportionate to each other. In rare cases, the inflammation of the throat may be of a gangrenous character, and extensive sloughing may take place in the pharynx or the cellular tissue of the neck, sometimes exposing or even opening the great vessels.

The duration of the symptoms in cases with severe angina is from seven to fourteen days. There is increasing prostration and finally a septic stupor, with death from exhaustion, from circulatory failure, or from some complication—bronchopneumonia, pleurisy, nephritis, hemorrhages following sloughing, pericarditis, or endocarditis. In patients who recover, the acute symptoms nearly always continue for a full month; and after escaping the dangers of sepsis and the early complications, the child has still to run the gauntlet of all the late complications—nephritis, pneumonia, endocarditis, and pyemia. A case may prove fatal as late as the end of the seventh week; nearly all such results are due to sepsis or nephritis.

*Special Symptoms.*—The pharyngeal inflammation extends regularly to the nasopharynx. There may be no special symptoms referable to the nose; on the other hand, there is often some degree of nasal obstruction, with a seropurulent, excoriating discharge, sometimes profuse. A certain degree of catarrhal inflammation of the sinuses, particularly the antra, and of the tympanic cavities, including the ear drums, characterizes a large proportion of moderately severe cases. Purulent sinusitis and otitis media are more properly regarded as complications.

Vomiting occurred at the onset in 80 per cent of 5000 cases analyzed by McCollom and Place. It seldom continues through the attack. Diarrhea is rare except in the very young. Meningismus may be marked early in the course, but other neurological signs are infrequent in uncomplicated cases. Cervical rigidity simulating that seen in meningitis may be due to tender, enlarged cervical lymph nodes.

Febrile albuminuria at the height of the disease is almost invariably present, with the elimination of pus cells and casts.

Sometimes there is a rapidly progressing anemia that lasts into convalescence. In mild cases there may be a moderate leukocytosis of from 12,000 to 16,000, but in severe types the reaction is more pronounced, appearing early, reaching a maximum about the fourth day, and gradually declining until the normal is reached, which may not be until the third, fourth, or fifth week. The maximum is usually about 30,000 to 35,000, although it may be as high as 75,000. During the first week the polymorphonuclear neutrophils form from 85 to 95 per cent. After the fifth or sixth day there is a rapid increase in the eosinophils, which attain their maximum—sometimes 20 per cent of the total leukocytes—between the fourteenth and twenty-first days. After the third week they gradually diminish. Complications, nephritis excepted, usually cause an absolute as well as a relative increase in polymorphonuclears. Blood cultures in the first few days are regularly negative. In severe forms of scarlet fever, especially those with marked angina, streptococci



are often recovered from the blood toward the end of the first week and thereafter. The finding of a few organisms in the blood does not necessarily mean an unfavorable prognosis.

**Relapses, Recurrences, and Second Attacks.**—As a rule, one attack of scarlatina gives immunity through life, second attacks *with a rash* being very rare.

Relapses or recurrences within a brief period after the first attack are more frequent. These are to be distinguished from cases of pseudorelapse, in which the rash, having temporarily subsided for two or three days, reappears; also from those where the rash varies in intensity from time to time; and, lastly, from cases in which, occurring late in the disease, the eruption is due to septicemia or pyemia. The true relapses are comparable to the relapses of typhoid fever. They occur most frequently during desquamation, between the seventh and twenty-fourth days. There may be not only a new eruption, but a rise of temperature, sore throat, and vomiting, just as in the initial attack. These recurrences are sometimes shorter and milder than the first attack, but this is by no means uniform, since Körner mentions 8 cases where the second attack proved fatal.

**Surgical Scarlet Fever.**—Any wound may become infected with scarlatinal streptococci and, with absorption of bacterial products, may give rise to all the general signs and symptoms of scarlet fever, including the eruption. The local manifestations in the throat, however, are lacking, and there is not the same liability to septic complications connected with pharyngitis—otitis, sinusitis, cervical adenitis—nor is subsequent nephritis so common.

**Complications and Sequelae.**—The most frequent complications are those depending on spread of the pharyngeal infection to adjacent structures, many of which have already been mentioned. Purulent *sinusitis*, when it occurs, usually develops toward the end of the first or second week. Suppurative *otitis media* may develop as early as the second day, or at any time during the course of the disease or in convalescence. In young patients and in severe cases it is rarely absent. The otitis of scarlet fever shows an extraordinary tendency to cause destruction of the tympanum and other structures in the tympanic cavity. It is one of the commonest causes of deafness. With a severe angina, suppurative processes may break out in the ears and mastoid antra with astonishing rapidity and violence. Simple *cervical adenitis* is a regular accompaniment of the disease, but continuance of the fever or even a late exacerbation a week or more after defervescence may be due to such origin. In some epidemics the glands show a great tendency to break down and form abscesses. Retropharyngeal abscess is merely a special localization of this process. Cellulitis of the neck fortunately is rare.

**Nephritis.**—Scarlet fever is particularly prone to be followed by acute diffuse nephritis with especially marked glomerular changes. It usually develops about the end of the third week of the disease, and may follow mild as well as severe cases. The onset may be gradual, with edema and urinary changes, usually accompanied by a slight rise of temperature; or it may be abrupt, without edema but with convulsions, suppression of urine, and very high temperature.

The characteristic urine is of a reddish or smoky color and scanty. It contains a large amount of albumin, often sufficient to render the urine solid upon boiling. Under the microscope there are seen red blood cells, epithelial cells, and casts of



every variety. Edema is present in at least 50 per cent of the cases. It may be slight or there may be general anasarca. There is loss of appetite and often vomiting. Pallor is frequently a striking symptom. Headache is common and persistent. The systolic blood pressure and the nonprotein nitrogen are often increased, and the phthalein excretion diminished.

The incidence and severity of nephritis vary in different epidemics. In large series reported it has occurred in anywhere from 1.5 to 9 per cent, the lower figures usually being derived from surveys of the community at large, rather than of hospital patients alone, where naturally the severe cases are concentrated. Ker has brought evidence to show that chilling of the patient, especially at the period when nephritis is apt to appear, is of importance in precipitating attacks. Most of the cases occur in children from five to ten years of age. The course of the nephritis does not differ from that of acute nephritis in general.

*Joints.*—Arthralgia and synovitis may occur coincidently with the development of the scarlatinal rash, but are seen more often during convalescence. These are probably toxic disturbances. They are difficult to differentiate from rheumatic fever, and indeed some authors like Coombs regard them as rheumatic manifestations. Serum sickness resulting from specific therapy may give a closely similar clinical picture. Occasionally suppurative arthritis of pyemic origin follows scarlet fever; the large joints are usually involved, and the lesions are apt to be multiple.

*Other Complications.*—Pneumonia, occurring as a complication of scarlet fever, usually appears during the febrile stage. It may be followed by empyema, which in septicemic cases is due to the scarlatinal streptococci. Systolic murmurs are exceedingly common during the course of the disease, but true endocarditis and pericarditis are rare. Streptococcus meningitis is not common, peritonitis even less so. Cases of symmetrical gangrene after scarlet fever have been reported, and are usually of septicemic origin. The parts generally affected are the fingers and toes, but it may occur almost anywhere. Noma is a very rare complication; it usually leads to death from toxemia or hemorrhage.

Of the other infectious diseases, diphtheria is most frequently seen as a complication of scarlet fever, and may be present even when there is no distinct membrane. Lowered resistance and defective isolation in institutions are the chief causative factors.

**Diagnosis.**—The characteristic symptoms of scarlet fever are the abrupt onset, usually with vomiting and marked elevation of temperature; the erythematous condition of the throat, the punctate eruption on the hard palate; the appearance of the rash within twenty-four hours, and later the characteristic appearance of the tongue. The difficulties of diagnosis usually depend upon irregularities in the eruption. The variations are seen in the mildest and in the most severe cases. In the former the rash may be of short duration, often less than a day, and in consequence easily overlooked; or it may be present only upon certain parts of the body instead of being diffuse. In every doubtful case the groins, axillae, and loins should be closely scrutinized for a punctate eruption. In very severe attacks the rash may appear late or recede after being fully out, or it may be hemorrhagic or in irregular blotches. In any case, too much stress should not be placed upon the rash alone. A history of exposure within a week carries considerable weight.



A throat culture showing no colonies of beta-hemolytic streptococci is fairly strong evidence against scarlet fever; a positive plate is of value if the streptococci are very numerous; to test out the toxin-producing power of the organisms is so time-consuming as to be of little practical value.

Sometimes the diagnosis remains doubtful until the end, although occasionally confirmatory evidence may be obtained even in convalescence. Thus, a patient may desquamate in a manner so typical as to leave no doubt as to the nature of the preceding illness; again, the occurrence of a characteristic sequel, such as nephritis in the third or fourth week, may testify strongly for scarlatina as the primary disease; and, finally, the outbreak of undoubted cases among children who have been in contact with the patient is practically conclusive, always provided other sources of infection can be excluded. Desquamation, however, follows so many other eruptions that, when slight or irregular, one should not rely upon it as an evidence of scarlet fever, but only upon a typical exfoliation upon the hands and feet. It is a point of some practical importance not to oil the skin of a patient when awaiting desquamation for diagnosis, as this alters very much the characteristic appearances. In some puzzling epidemics the length of the incubation may be of material assistance in the diagnosis; when this is regularly more than a week, one may be pretty sure that one is not dealing with scarlet fever.

Scarlet fever with severe throat symptoms and a doubtful eruption can be distinguished from diphtheria only by cultures. Nasal diphtheria is easily missed, and in all cases it is sound policy to make careful search for Klebs-Löffler organisms in cultures from both the nose and throat. Measles is distinguished by the length of the invasion, the catarrhal symptoms, and the slowly spreading eruption; most of all by Koplik's spots. There is usually a leukopenia in measles and a leukocytosis in scarlet fever. Much more difficult is it to distinguish between mild scarlatina and rubella. In rubella the important thing is that, although the rash may be well marked, often covering the body, the constitutional symptoms are few or entirely absent. In scarlet fever with an eruption of the same intensity there is almost invariably a considerable elevation of temperature, usually 102° to 103° F., and a bright red throat.

There are so many skin eruptions which may resemble that of scarlet fever, that it is always hazardous to make the diagnosis of this disease from the eruption alone. This is especially true of sporadic cases occurring in infants; there are seen at this age a great variety of eruptions, usually associated with digestive disturbances, which closely simulate a scarlatinal rash; but most of them are of short duration. A scarlatiniform erythema is occasionally seen in serum sickness, also in influenza, typhoid fever, pneumonia, and varicella, which may cause them to be mistaken for scarlet fever, or may lead to the conclusion that both diseases are present. Belladonna, quinine, and occasionally antipyrine, the salicylates and aspirin may produce eruptions more or less closely resembling that of scarlet fever. This is also true of some cases of urticaria and other forms of skin disease. Eruptions resembling scarlet fever may also arise from irritation due to clothing, to heat, and to the local application of irritants to the chest. There is little doubt that many of the cases reported as relapsing scarlatina are really examples of recurring erythema, particularly as some of the latter are followed by a desquamation which



is very similar to that after scarlatina. Except in cases of surgical scarlet fever, the rash is of little significance unless associated with characteristic changes in the pharynx.

In 1918 Schultz and Charlton described a test which is frequently known by their names or as the "extinction test." This consists in the intracutaneous injection of 1 c.c. of the serum of a normal person or one convalescent from scarlet fever into the reddened skin of a patient with supposed or actual scarlet fever. If the disease is scarlet fever a blanching several centimeters in diameter occurs in the course of five or six hours. Other rashes are not affected by such an injection. Serum from a patient acutely ill will cause no blanching. The test is positive

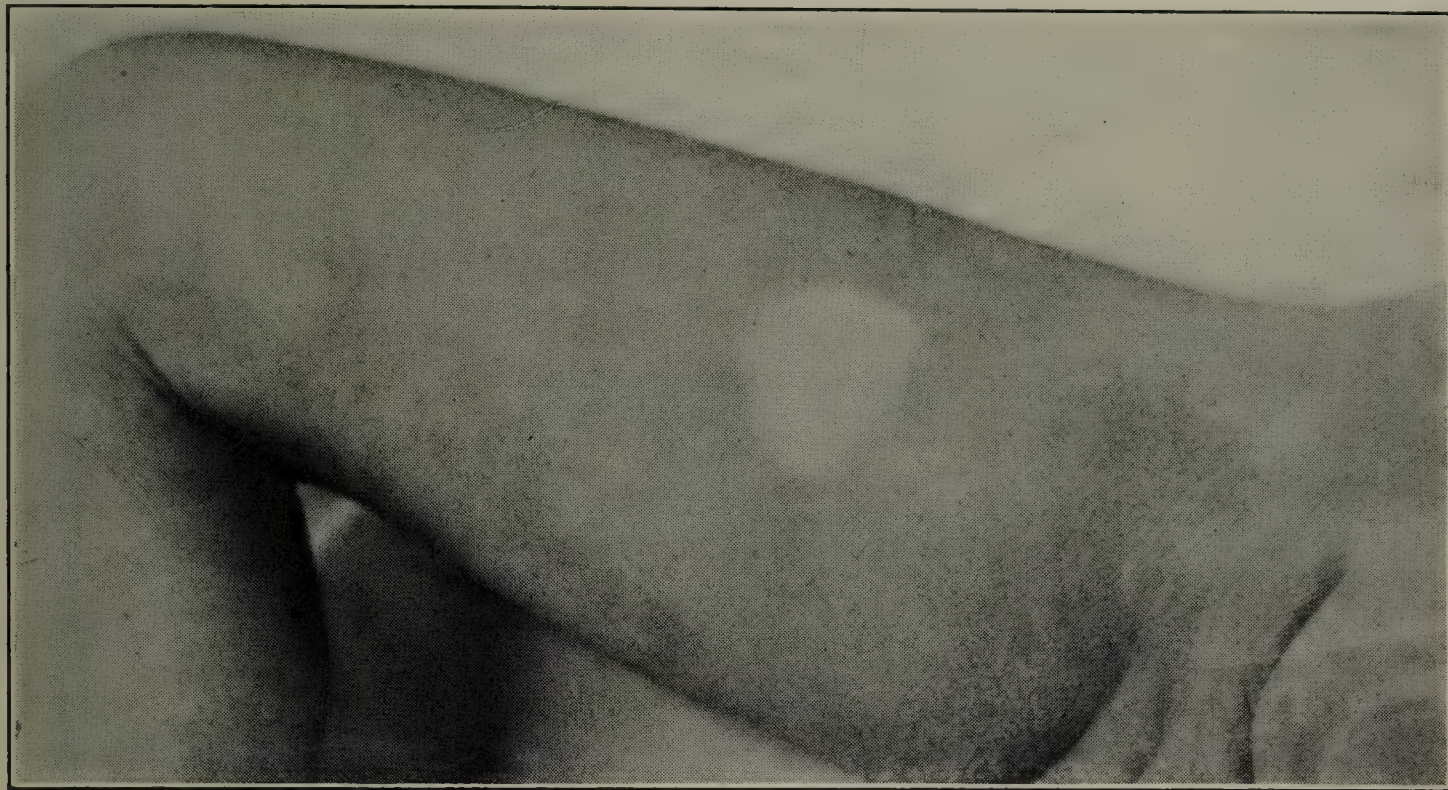


FIG. 142.—BLANCH OR EXTINCTION REACTION IN SCARLET FEVER—SCHULTZ-CHARLTON PHENOMENON.

in the majority of true cases but not in all. A better test is the injection of 0.2 c.c. of a potent therapeutic serum. This brings about rapid and permanent blanching if injected a few hours after the appearance of the rash (Fig. 142). The area where blanching has been produced desquamates slightly if at all. The test is often of great help but too much reliance should not be placed upon a negative result.

**Dick Test.**—The Dick test<sup>2</sup> is a valuable means of determining susceptibility to scarlet fever. Those who have natural immunity (*e.g.*, newly born infants) and individuals who have acquired antitoxin react negatively. The test is also of diagnostic importance; at the height of the disease it is negative but usually becomes positive about the time the rash fades. A persistently positive or persistently negative Dick test casts doubt upon the diagnosis.

**Prognosis.**—There is no disease in which it is more difficult to foretell the outcome than scarlet fever. Cases apparently mild not infrequently develop serious symptoms and complications. Symptoms indicating a bad prognosis are: very high temperature, especially one which continues to rise the first three or four days,

<sup>2</sup> An intradermal injection of 0.1 c.c. of a carefully standardized toxin containing 10 skin test doses per c.c. is made on the flexor surface of the forearm. The reaction is read at the end of twenty-four hours. An area of reddening, usually 1 to 2 centimeters in diameter, appears in that time in susceptible persons.



and severe nervous and throat manifestations. Few patients, except those who succumb in the first two or three days of the attack, die from the toxemia of the disease itself. Most deaths occur toward the end of the first week, especially in those patients with severe angina and with streptococci in the blood. Many die from the complications. The mortality of scarlet fever varies much in different epidemics. In some, nearly all the cases are of a mild type, and the mortality may be as low as 3 or 4 per cent; in others, a severe or malignant type prevails, and it may be as high as 40 per cent.

The general mortality of the disease in hospitals may be assumed from numerous reports to be between 10 and 15 per cent. The mortality in entire cities

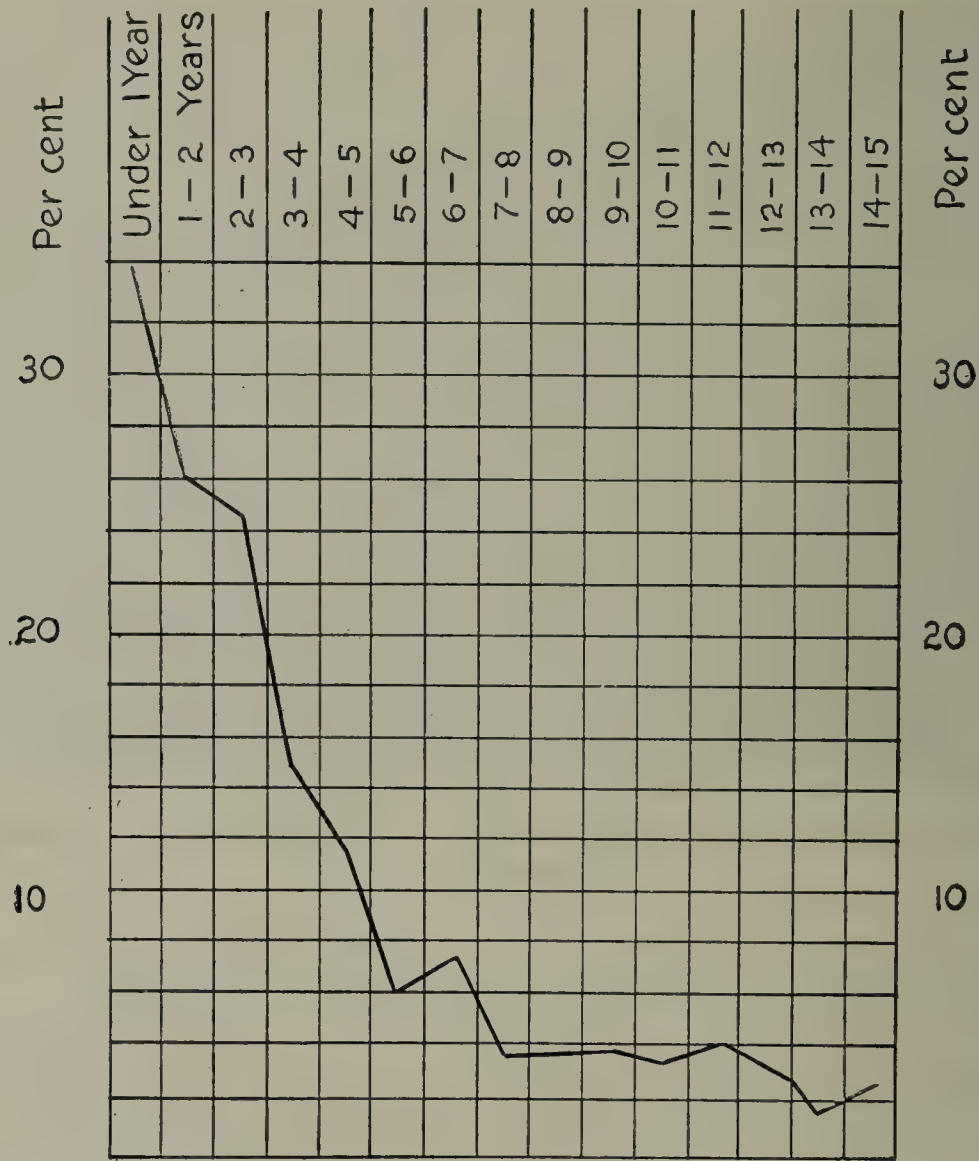


FIG. 143.—MORTALITY AT DIFFERENT AGES IN 5000 HOSPITAL CASES OF SCARLET FEVER. (From McCollom and Place.)

is not so high; some show for years a mortality of only 5 or 6 per cent. It is much higher in young children, as shown by the accompanying chart. Under three years of age the average mortality from scarlet fever in hospitals is between 20 and 30 per cent. There is no doubt that the mortality from scarlet fever is gradually becoming less throughout all the civilized world. The reason for this is by no means clear.

As a cause of permanent deafness and deaf-mutism, no disease of childhood compares in importance with scarlet fever. May has collected statistics of 5613 deaf-mutes, of whom 532 owed their condition to otitis following scarlet fever.

Streptococcal meningitis is almost invariably fatal. We have, however, seen



two recoveries, complete in one, in the other with psychic and neurological residua. Both were given intraspinal injections of antiscarlatinal serum.

**Treatment.**—The application of specific serum therapy since 1924 has caused a distinct improvement in the prognosis, even though not as striking as that following the discovery of diphtheria antitoxin. A potent serum if given early exerts a prompt and dramatic effect on the toxemia and the eruption, often causing a sudden drop of temperature, complete disappearance of the rash, and abatement of malaise within twenty-four hours. It is questionable if the local process in the throat or the incidence and severity of complications are affected. To be helpful,

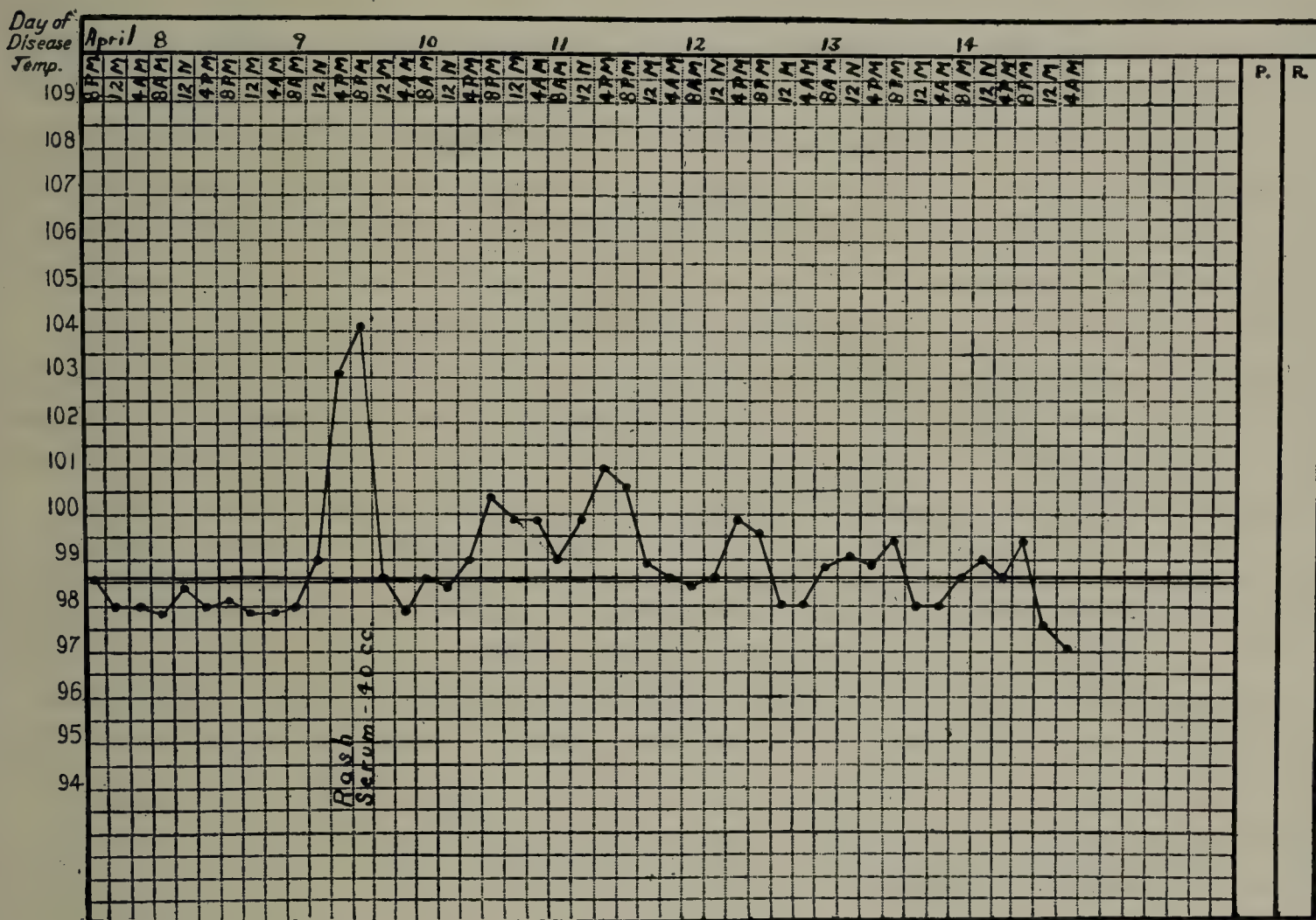


FIG. 144.—TEMPERATURE CHART OF SEVEN-YEAR-OLD PATIENT TREATED ON FIRST DAY OF SCARLET FEVER WITH 40 C.C. ANTISCARLATINAL SERUM.

serum must be given early, before the eruption has begun to fade. Under these circumstances it may even prevent subsequent desquamation.

In recent years most cases of scarlet fever have been mild, and it seems doubtful whether such should be given serum. The discomfort of serum sickness and the resulting sensitization of the patient are serious drawbacks. Blake recommends the use of serum when there are indications that the infection is to be a severe one—with unusually severe toxic manifestations at the start, with a nasal discharge, with membrane in the throat or in the presence of large tonsils. In the absence of any of these indications it may be omitted. The minimum dose is 10,000 units, and it is probably advisable to give two or three times this dose at frequently repeated intervals in the severest cases. Unfortunately many of the sera on the market as recently as 1931 have been found by Wadsworth and others to be of such low potency as to offer but little advantage to the patient.



Human convalescent serum has been used with considerable success both in this country and abroad. It is difficult to obtain except in contagious disease hospitals, and, on account of the relatively low titer, larger amounts are required. It avoids serum disease.

Aside from serum therapy the physician's duty consists in: (1) establishing proper quarantine and the carrying out of adequate means of disinfection; (2) the hygienic care of the patient; (3) directing the diet; (4) watching for complications, especially otitis, diphtheria and nephritis.

Mild attacks require no medicine. Children should be kept in bed at least a week after the fever has subsided, and put on a bland diet with high fluid intake.

The throat requires no local treatment. Obstructed nasal breathing may yield to the instillation of ephedrine solution. For nervous symptoms, especially if associated with pyrexia, sponge-baths, alcohol rubs, or colonic irrigations are helpful. Aspirin is occasionally useful to control restlessness and promote sleep. If there are signs of circulatory failure, epinephrine, caffeine, or digitalis may be given.

Mild forms of adenitis require no treatment. In severe forms, an ice-bag should be applied continuously. Abscesses call for appropriate surgical treatment.

The ears of patients with severe throat symptoms should be examined daily in order that there may be no delay in performing paracentesis should this become necessary. It is generally felt that operative treatment of scarlatinal otitis media and mastoiditis must be more radical than in other types of infection.

The physician should be constantly on the watch for the development of nephritis, especially from the eighteenth to the twenty-second day. The nurse should be instructed to measure and record accurately the twenty-four hour urine throughout the attack. Chilling of the patient is to be avoided. The treatment of scarlatinal nephritis does not differ from that of acute nephritis from other causes.

*Quarantine.*—Even the mildest cases of scarlet fever should be isolated for four weeks; and if complications with any purulent discharge persist, quarantine should be prolonged until these have been shown to be free from beta-hemolytic streptococci. The quarantine regulations in different communities differ considerably, however. For contacts, one week's observation usually suffices to show whether scarlet fever has been transmitted.

The precautions required of the nurse and the care of the patient and of the sick room during and after the attack have been considered in the introductory pages of this section.

Schools are hot-beds for the spread of scarlet fever. The greatest sources of danger are the mild, ambulant cases in which the disease has not been recognized and recovered patients in whom otitis or sinusitis lights up after release from quarantine. During severe epidemics it frequently becomes necessary to close all schools.

*Prophylaxis.*—Active immunization<sup>3</sup> has been widely practiced with culture filtrates of the specific organisms. Although there is no doubt that by this means

<sup>3</sup> The measure of standardization is the *skin test dose*, the smallest amount of filtrate required to give a positive Dick test in susceptible persons. The injections should be made subcutaneously at weekly intervals of increasing amounts, beginning with 500 S.T.D. and ending with 80,000 or 100,000 S.T.D. at the fifth injection. After an interval of two weeks, the Dick test is repeated with both 1 and 2 S.T.D. and if found positive



an immunity lasting two years or more can be produced, it is still an open question whether this is of any value. The immunity conferred by this procedure applies to clinical scarlet fever rather than to infection with scarlatinal streptococci. It is clear that infections with these organisms can and frequently do occur in individuals with antitoxin in their blood, and that such infections are sometimes followed by nephritis. It is of course conceivable that individuals with circulating antitoxin are somewhat less likely to develop subsequent infection with these organisms, or that, even if they do acquire such infections, they will have milder attacks and a lower incidence of complications. These questions can be answered only by statistical data which are not yet available. Until such hypotheses are proven, it remains doubtful whether immunization accomplishes anything more than protection against the rash alone. The same applies to the transient passive immunity conveyed by prophylactic injections of antitoxic serum.

Epidemics must be controlled by prompt isolation of cases and contacts, and detection of sources of danger by throat culture for beta-hemolytic streptococci.

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the patient is given a sixth injection. About 10 per cent of all subjects give reactions at some stage of the course; there may be local pain, tenderness, and swelling, fever, and sometimes the appearance of a scarlatiniform eruption in the first day or two after inoculation. In from 5 to 9 per cent a demonstrable loss of immunity has been found in the course of from one to three years.



## CHAPTER CXIX

### MEASLES

Measles (*rubeola*, *morbilli*) is an epidemic contagious disease, more widely prevalent than any other eruptive fever; very few persons reach adult life without contracting it. One attack usually confers immunity. It is highly contagious even from the beginning of the invasion, and spreads with great rapidity from the patient to all susceptible persons exposed. The infectious agent, however, does not cling to clothing or objects as does that of scarlet fever. Measles has a usual incubation period of from eleven to fourteen days, a gradual invasion of three or four days with symptoms of an acute coryza, and a maculopapular eruption which appears first upon the face and spreads slowly over the body, and which lasts from four to six days. This is followed by a fine bran-like desquamation, which is complete in about a week. The mortality is low, except among infants and delicate children, in whom it may reach 30 or even 40 per cent. In institutions for infants and young children no epidemic disease is more to be dreaded than measles, not so much on account of its severity, as from the frequency with which, in such subjects, it is complicated by interstitial bronchopneumonia.

**Etiology.**—Little is as yet known of the essential cause of measles. Anderson and Goldberger, Blake, Trask and others, have inoculated monkeys with the blood and also with the nasal and buccal secretions from patients with measles and have produced a disease attended by fever, eruption and respiratory symptoms which is believed to be identical with measles in the human subject. Blood from patients with measles was found to be infective at least twenty-four hours before the eruption and for twenty-four hours after its appearance. Later than this its infectivity is much lessened and soon disappears. The secretions from the mouth and nose were infective for the monkey only when collected during the stage of eruption. Some capable experimenters have not been successful in conveying the disease to monkeys, so that it cannot be said that the artificial transmission of measles to animals has received universal confirmation. No organisms have been recognized which can be looked upon as the infecting agent, and the evidence points to a filtrable virus as the cause. Anderson and Goldberger were able to reproduce the disease with Berkefeld filtrates. Degkwitz claims to have cultivated the virus.

Tunncliffe has cultivated an anaerobic green streptococcus from measles cases. Filtrates of this organism produce a skin reaction which is neutralized by the serum of persons who have had measles. By most authorities the Tunncliffe streptococcus is regarded as a secondary invader.

Clinical observations indicate that the virus of measles is more readily diffused than that of most communicable diseases; also that its viability is less than that



of most pathogenic organisms. Only a short exposure is required to communicate the disease.

*Predisposition.*—Infants under six months do not readily contract measles, but all other children are extremely susceptible. In an epidemic reported by Smith and Dabney, 110 unprotected children, between the ages of eight and eighteen years, were exposed and only 2 escaped. In one institution epidemic observed by us there were 62 children over two years of age; 5 were protected by a previous attack and escaped; of the remaining 57 children, 55 took the disease. There were also in the institution 113 children under two years old; of this number 78 per cent took the disease; but, although a number were exposed, not one child under six months old contracted measles. We have, however, seen at least 3 instances of typical measles in infants of four and five months. No immunity develops with age. In the celebrated epidemic in the Faroe Islands in 1846 practically only those persons escaped who had had measles at a time when the disease had prevailed sixty-five years before. The immunity of the newly born appears to be a passive immunity acquired from the mother. The Faroe Islands epidemic demonstrated that infants born of nonimmune mothers were quite as susceptible as adults. Instances have been reported by Somer, Gautier and others in which the eruption of measles has either been present at birth or has developed within a few hours after birth, when the mother was suffering from the disease at the time.

Except, then, in early infancy, the probabilities are very strong that every child exposed to measles will contract the disease. Occasionally, however, one is seen who seems insusceptible, no matter how close the exposure.

Epidemics of measles are more frequent and more severe during the winter and spring months. They are least frequent and mildest during the summer and autumn months. In large centers of population the incidence of measles shows a very marked increase in alternate years. Thus, in New York City the even years during the last decade have shown a high incidence, whereas there has been little measles in the odd years (Fig. 145).

*Incubation.*—In 144 cases in which the period of incubation could be definitely traced, it was as follows:

<i>Incubation Period</i>	<i>Cases</i>
Less than nine days.....	3
Nine or ten days.....	22
Eleven to fourteen days.....	95
Fifteen to seventeen days.....	19
Eighteen to twenty-two days.....	5

Thus in 66 per cent of the cases the incubation was between eleven and fourteen days, and in only one case was it less than a week. The constancy of the incubation period is strikingly shown in some epidemics. Thus in the one reported by Smith and Dabney in an institution in Virginia, exactly eleven days after the rash appeared in the first case, the disease developed in 20 children—no cases having occurred in the interval.

*Duration of the Infective Period.*—This is much shorter than in scarlet fever,



and the average duration may be placed at two weeks. The period of isolation need not be more than a week after the appearance of the eruption.

Measles is highly contagious from the very beginning of the catarrhal symptoms. A case occurred under our observation in which a child conveyed the disease four days before the rash appeared; and many such have been observed. An instance is known to us where, of 13 little girls at a children's party, only 1 (protected by a previous attack) escaped measles; the source of infection was a child who showed no rash until the following day. The period during which the disease is most contagious is still a matter of dispute, the general belief being that it is coincident with the most severe catarrhal symptoms and the beginning of the eruption. With the fading of the eruption and the subsidence of the catarrh,

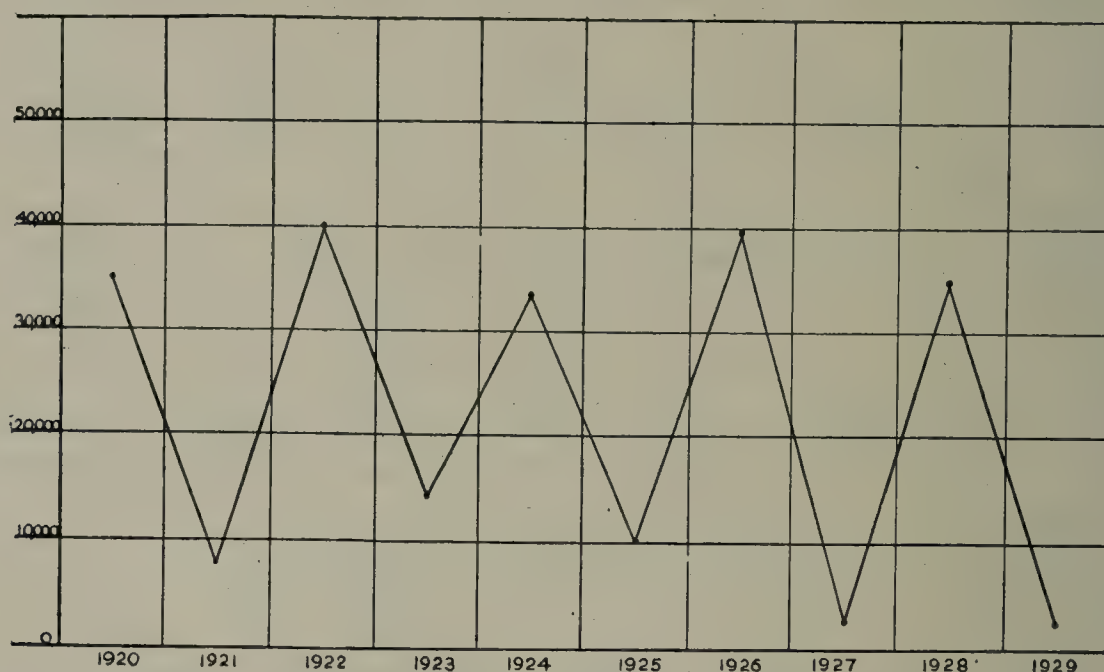


FIG. 145.—INCIDENCE OF MEASLES IN NEW YORK CITY.

the communicability of measles diminishes rapidly. The virus has never been demonstrated in the skin lesions.

*Mode of Infection.*—Measles is usually spread by direct exposure to an affected person. There is every reason to believe that the infectious agent is chiefly disseminated by the minute droplets which are given off during coughing and sneezing, probably also by the discharges from any affected mucous membrane. Proximity to a patient seems necessary to contagion, but not actual contact. Infection from the scales during desquamation certainly does not occur. It is very infrequent that measles is conveyed through the medium of clothing, furniture, or a third person. Though a good many instances are on record in which the disease has been carried by a third person, this, after all, very rarely happens and we think never unless the contact both with the sick and well child is very close and the interval short.

*Pathology.*—The only constant lesions of measles are those of the skin and the mucous membranes, chiefly of the respiratory tract.

The process in the skin is of an inflammatory character. There is an exudation of serum, wandering phagocytes and a few red cells into the superficial portion of the corium, and eventually into the epidermis. This is especially marked about the blood vessels of the papillae, the hair follicles and the sebaceous glands. To



this exudation and edema the swelling of the skin is due. It occurs everywhere, but is especially noticeable upon the face. Eventually there is desquamation of the superficial portion of the epidermis and the rest of the exudate is absorbed.

The changes in the mucous membranes are quite as much a part of the disease as those of the skin. There is a catarrhal inflammation affecting the conjunctivae, nose, pharynx, larynx, trachea, and large bronchi, which varies in intensity with the severity of the attack. In severe cases, the lesion in the pharynx and larynx also, instead of being catarrhal, may be membranous. The larynx is much more frequently involved, and the ears much less so, than in scarlet fever. Areas of focal necrosis in the liver have been described by numerous observers. Although lesions of the lungs have usually been regarded as entirely due to secondary invaders, there is some evidence that the virus of measles itself damages the lung. Denton, Feyrter and others have pointed out that pulmonary involvement may occur at the onset of the disease.

The bacteria usually associated with lesions of the respiratory tract are streptococci, pneumococci, and influenza bacilli. Rarely is one variety found alone. Staphylococci are often found but less frequently than the other organisms mentioned. Measles produces conditions in the mucous membranes of the respiratory tract which are especially favorable for the development of these bacteria. They are present in the mouth in great numbers; they may cause pneumonia, otitis, or other local inflammations, and the pneumococcus or streptococcus may produce a general septicemia.

**Symptoms.**—*Invasion.*—As a rule, the invasion of measles is gradual, both the fever and catarrhal symptoms increasing steadily up to the appearance of the eruption. The characteristic symptoms of the invasion are those of a severe coryza: suffusion of the eyes, increased lacrimation, photophobia, sneezing, and a discharge from the nose. A hoarse, hard cough indicates that the catarrhal process has involved the larynx and trachea, as well as the visible mucous membranes. Frequently the patient complains of some soreness of the throat, and on inspection there is seen moderate congestion of the tonsils, fauces, and pharynx. On the hard palate are frequently seen small red spots. Much more characteristic are the minute white spots upon the mucous membrane of the cheeks, known as Koplik's spots. They are of great diagnostic importance, and are found in no other condition. The unit of the eruption is a bluish- or yellowish-white speck from 0.3 to 1 millimeter in diameter and slightly raised, surrounded by a red areola which is generally a little wider than the white spot itself. Koplik's spots are found from two to four days before the appearance of the skin eruption. For the first twenty-four or thirty-six hours there are only a few to be seen on the buccal mucous membrane opposite the molar teeth. They increase rapidly in numbers so that the interior of the cheeks may become fairly peppered with them, and the areolae coalesce. The spots are best seen in a strong light; by inexperienced observers they are frequently overlooked. At the time of full eruption they disappear. There is no local pain or other sensory disturbance.

The constitutional symptoms are those of almost any acute febrile disease—dullness, headache, pains in the back, and the usual symptoms of malaise; there is rarely vomiting or diarrhea. Drowsiness is a frequent symptom.

The exceptional cases in which the invasion is abrupt are puzzling. There may



be a sudden accession of fever with vomiting, and even convulsions. Not infrequently when the disease prevails epidemically, the invasion is sudden, with high fever and pulmonary symptoms which are so severe as to mask everything else until the rash makes its appearance, the case up to that time being often regarded as one of primary pneumonia. The duration of the stage of invasion—*i.e.*, from the beginning of the catarrh until the eruption—in 270 cases which we have analyzed was as follows:

Days	Cases	Days	Cases
1 or less.....	35	6 .....	20
2 .....	47	7 .....	6
3 .....	64	8 .....	2
4 .....	64	9 .....	2
5 .....	29	10 .....	1

From this table it will be seen that the length of the period of invasion varies considerably—more, we think, in infants and very young children (most of these were under three years old) than in those who are older. In the greater number of cases it lasts from two to four days.

*Eruption.*—Prodromal eruptions are rather uncommon but are occasionally seen during the period of invasion in the form of erythemas or urticaria. Probably the most frequent is an abortive type of the typical measles eruption which appears for a few hours and rapidly fades, to be followed later by the definite eruption. The characteristic rash usually appears on the third, fourth, or fifth day of the disease—in the largest number upon the fourth day. As a rule, it is first seen behind the ears, on the neck, or at the roots of the hair over the forehead. It appears as small, dark red spots, which are at first few, scattered, and not elevated. In twenty-four hours the macules are much more numerous, and have become slightly elevated so that they are in reality papules and can be appreciated by the fingers. These papules are pinkish with a slightly dusky tinge and stand out in striking contrast to the intervening skin which is not changed in color. The papules are very irregular in outline. They disappear on pressure but it is not infrequent for them to be slightly hemorrhagic, even in cases of no great severity. From the time of its first appearance to the full development of the rash on the face is usually about thirty-six hours, but may be from one to three days. With a full eruption there is seen considerable swelling of the face, especially about the eyes, and the features are sometimes scarcely recognizable. On the second day of the rash it begins to appear upon the neck beneath the chin, and on the upper part of the chest and back; on the third day the trunk is covered, and scattered spots are seen upon the extremities. The rash appears last upon the lower extremities, and by the time it is fully out upon them it has usually begun to fade from the face. In mild cases it remains discrete, but in severe ones it is frequently confluent upon the face, abdomen and upon the extensor surfaces of the extremities. As a rule, it covers the entire body, even the palms and soles.

The eruption fades slowly in the order of its appearance, and there is left behind, in typical cases, a slight brownish staining of the skin which often remains for a week or more. The duration of the rash is from one to six days, the average being four days.



PLATE III



1. Koplik's spots,  
early stage

1



2. Koplik's spots,  
full-blown enanthem

2



3. Aphthous stomatitis  
(canker sore)

3







There are many cases in which the rash does not follow the typical course described: (1) Instead of spreading gradually, the entire body may be covered in a few hours. (2) The rash may be intensely hemorrhagic. In such circumstances petechial spots take the place of the macules—the “black measles” of the



FIG. 146.—MEASLES AT THE HEIGHT OF THE ERUPTION.

older writers. Hemorrhage from the mucous membranes, mouth, nose and intestinal tract may also appear. This constitutes a very serious but fortunately extremely rare type of measles; we have never seen such a case. (3) The rash may be very faint, and of short duration, being scarcely elevated at all. (4) It may consist of very minute papules, closely resembling the rash of scarlet fever. It is to be



remembered, however, that the irregular eruptions of scarlet fever much more frequently resemble measles than *vice versa*. (5) It may be very scanty, and late in its appearance, particularly in cases of great severity and hyperpyrexia—the so-called malignant cases. (6) Temporary recession of the eruption may occur at any time during the height of the disease, and is usually due to circulatory failure. A recurrence of the eruption after it has run its usual course is something which we have never seen; although such cases have been reported, they must be regarded as very exceptional.

During the first two days of the eruption, the local and constitutional symptoms increase in severity, both usually reaching their maximum at the time of the full development of the rash upon the face. The skin is slightly edematous, and the seat of moderate itching and burning. The eyes are very red and sensitive to light, and there is swelling of the conjunctivae with an abundant production of mucus or mucopus, causing the lids to adhere. There is pain on swallowing, also swelling of the glands at the angle of the jaw or in the postcervical region. The cough is frequent and very annoying; it is often dry and croupy. There is complete anorexia, and often diarrhea. The tongue is coated, and may show at its margin enlarged papillae, somewhat resembling the “strawberry” appearance of scarlet fever. As the rash fades the temperature declines rapidly, often reaching the normal in two or three days. The catarrhal symptoms now subside, and soon the patient is convalescent. Within a day or two after the fever has ceased the rash disappears.

*Desquamation*.—This begins almost as soon as the rash has subsided, and is first noticed on the face and neck, where the eruption first appeared. The nature of the desquamation is invariably fine, branny scales, never in large patches, as in scarlet fever. It is often quite indistinct and may be overlooked. Its usual duration is from five to ten days. It may, however, be prolonged for two weeks. The amount of desquamation varies considerably in the different cases. It is most marked in those in which there has been an intense eruption. There is frequently noticed at this time an odor about the patient which is quite characteristic of measles. During this stage the cough often persists and the eyes remain very sensitive to light, but in other respects the patient usually feels perfectly well.

*Mild Cases*.—The mildest cases are distinguished by low temperature, which at the height of the eruption usually reaches 102.5° or 103° F., but rarely lasts more than four days. The eruption is often scanty, and is never confluent. The swelling, itching, and other cutaneous symptoms are wanting, as is also the intense red color of the skin. The rash is frequently obscure, and, without the other symptoms, hardly sufficient for diagnosis. The catarrhal symptoms are more uniform than the rash, but these are very mild as compared with the usual form. The duration of the rash is shorter, desquamation is scarcely perceptible, and there are no complications.

*Cases of Moderate Severity*.—The course of measles is much more regular in children over three years old than in infancy. In the former, the symptoms of invasion come on gradually, and the temperature rises steadily until the appearance of the eruption, which is in most cases on the third or fourth day of



the disease. Figure 147 represents the typical temperature curve in average uncomplicated cases. Such a curve was seen in 44 per cent of 173 cases in which careful observations were made. Sometimes the decline in the fever is rapid, almost by crisis, but more often it falls gradually. In such cases the duration of the fever is from five to nine days, the average being about a week. The other symptoms follow very closely the course of the fever. The maximum temperature is nearly always coincident with the full rash upon the face, at this time usually being in uncomplicated cases from 103° to 104° F. in older children, and 104° to 105° F. in infants and young children.

A not uncommon temperature curve is one in which the onset of the disease is marked by a sudden rise to 102° or even 104° F., with a fall nearly or quite to normal on the second day, after which the fever rises gradually, as in the first group. This curve was seen in about 5 per cent of our cases.

*Severe Cases.*—In Figure 148 is shown a type of the disease which is more frequent in infants than in older children, the important features being the late eruption and the continuance of the high fever for several days after the rash has begun to fade. Such a prolonged course and so high a temperature are almost invariably due to some complication, usually bronchopneumonia. When the pneumonia goes on to the production of large areas of consolidation, the fever usually continues for three and sometimes for four weeks, even though terminating in recovery.

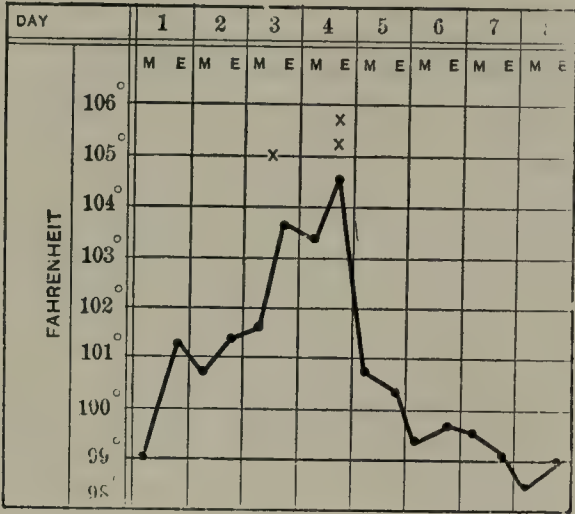


FIG. 147.—TEMPERATURE CURVE IN UNCOMPLICATED MEASLES, SHOWING THE GRADUAL RISE AND CRITICAL FALL.

Patient ten years old; X = first eruption; X X = full eruption on the face.

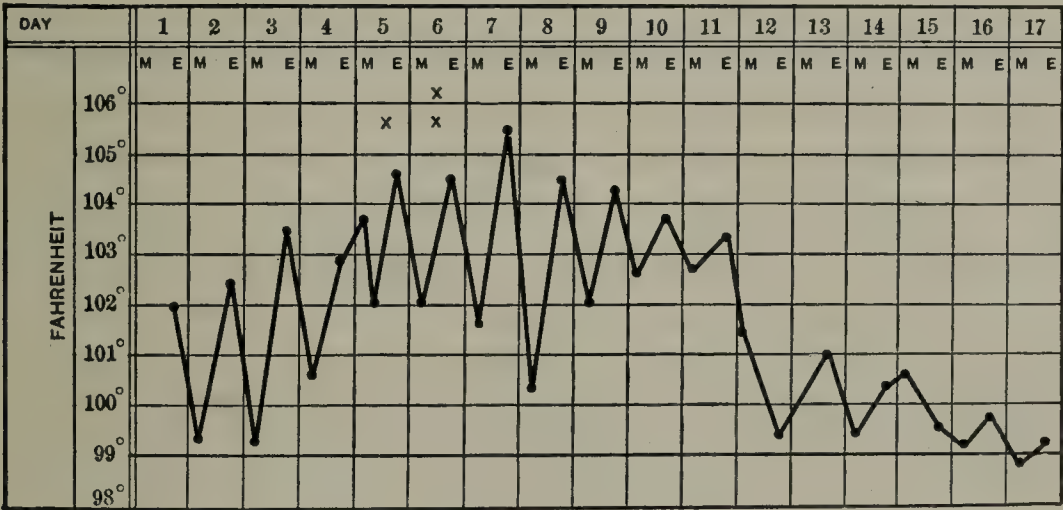


FIG. 148.—MEASLES WITH PROLONGED INVASION.

Continuance of high temperature after full eruption due to pneumonia, with diarrhea; child two years old. X = first eruption; X X = full eruption on the face.

Figure 149 illustrates a type of the disease which is often seen when measles is complicated by pneumonia. The onset is abrupt with high temperature, prostration, and pulmonary symptoms not unlike those of primary pneumonia. A temperature curve resembling this was seen in 28 of 173 cases. The rash is often late



in appearance; it is faint and altogether irregular; it may recede after the first day and reappear after an interval of one or two days. The catarrhal symptoms are not marked, but the whole force of the disease seems to be expended upon the lungs. The diagnosis of these cases presents great difficulties, and often it would not be made but for the fact that there are other cases of measles in the family or the institution. This form is most often seen in infants, and it is usually fatal.

In other cases marked by a sudden severe onset, the system seems to be overpowered by the poison of the disease itself. There is profound depression, and

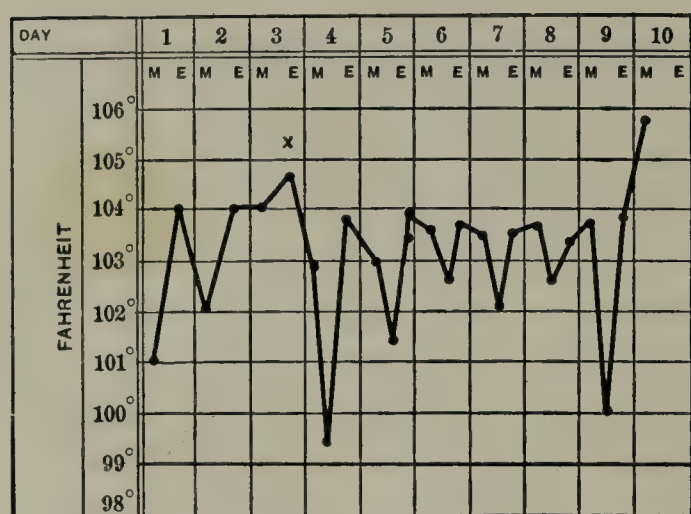


FIG. 149.—FATAL ATTACK OF MEASLES, COMPLICATED BY BRONCHOPNEUMONIA.

Very severe symptoms from the onset; patient eighteen months old; death on tenth day. X = first eruption.

hyperpyrexia, and the patient may die from toxemia with cerebral symptoms before the appearance of the rash or just as it is beginning to show itself. Sometimes the pulmonary symptoms are entirely wanting; at others the rash, if it appears, is hemorrhagic.

In still another group of cases the onset is not violent, and for the first two days the attack may appear to be of only average severity; but there may then develop, often quite suddenly, pulmonary symptoms of such intensity as to cause death within twenty-four hours. The eruption, if seen at all, is faint and not characteristic.

A secondary rise in the temperature after it has once fallen to normal is rare

and usually due to the development of otitis, pneumonia, or some other infection.

**Complications and Sequelae.**—*Respiratory Tract.*—A catarrhal angina, accompanied by pharyngitis and tracheitis, is part of the disease, quite as characteristic as the eruption, and is not to be regarded as a complication. Bronchitis of the large tubes is seen in every case of measles, possibly excepting a few of the very mildest. In nearly all of the severe cases the bronchitis extends to the medium-sized and smaller tubes. A persistent cough often remains for some weeks. A mild catarrhal laryngitis accompanies almost every case of measles. Severe catarrhal laryngitis is present in about 10 per cent of the cases.

Local inflammations of great severity are sometimes seen in the pharynx, tonsils and larynx; they are usually streptococcal. These complications are much more common in institutions. The process may be membranous and give rise to clinical manifestations indistinguishable from diphtheria. Membranous laryngitis is not necessarily associated with pharyngitis and tonsillitis, but this is usually the case. The process is quite as serious as in diphtheria, and may require similar local treatment. Necrotic changes occasionally take place. We once saw an instance in which, although no false membrane was present in the rest of the larynx, there was a necrotic inflammation with almost entire destruction of the vocal cords. True diphtheria may occur in the course of measles.

The most frequent and most important complication of measles is interstitial



bronchopneumonia, and next to this are otitis and membranous laryngitis. Pulmonary complications are most frequently found in children under two years of age. In two institutional epidemics, comprising about 300 cases, nearly all in children under three years old, bronchopneumonia occurred in about 40 per cent of the cases. Of those who had pneumonia, 70 per cent died. Fortunately, such a record as this is never seen outside of institutions for young children. Of 2477 cases, embracing several epidemics of measles among children of all ages, pneumonia occurred in 10 per cent. Our own experience in the postmortem room fully bears out the statement of Henoch, that a certain amount of pneumonia is found in practically every fatal case. Pneumonia is more frequent and its mortality is higher in spring and winter epidemics than in those occurring at other seasons. It may develop at any time from the beginning of invasion until convalescence, but it usually begins about the time of full eruption. In some epidemics many of the cases of pneumonia are complicated by pleurisy, which is frequently followed by empyema. Pneumonia is always to be suspected when the temperature continues high after the full appearance of the rash.

Kohn and Koiransky have shown that roentgenological evidence of pneumonia is present in more than half of the cases of measles in young children, even though physical signs are absent. The mediastinal lymph nodes are often considerably enlarged even when pneumonia is not present. This enlargement may persist into convalescence, causing a chronic dry cough.

*Otitis*.—This is a very common complication of measles, and is usually due to streptococci, sometimes to other organisms. The destructive processes in the tympanic cavity which so commonly occur in scarlet fever are, however, rare in measles.

*Adenitis*.—Suppurative or phlegmonous cervical adenitis occurs in some of these severe cases. Although in most instances of measles the local septic processes are not serious, they may be quite as severe as those seen in scarlet fever. Death from general sepsis may result.

*Digestive System*.—Gastric disorders are not more common than in other febrile diseases; but in infants diarrhea is very frequent, and in summer it may be even more serious than the pulmonary complications. The most severe intestinal symptoms are not usually seen at the height of the primary fever; but, beginning at this time, they often increase in severity, and are most marked in the second and third weeks of the disease.

Ulcerative stomatitis is not uncommon. One of the worst complications of measles, but fortunately a rare one, is gangrenous stomatitis, or noma. This usually occurs in inmates of institutions, or in children with bad surroundings who were previously in wretched condition. It is nearly always fatal.

Gangrenous inflammations of other parts of the body are sometimes seen after measles, especially of the ear, the vulva, or the prepuce.

*Nervous System*.—It is now clearly recognized that encephalitis is one of the infrequent complications of measles. This is described in detail under Diseases of the Nervous System (p. 851).

*Kidneys*.—A febrile albuminuria is common enough, but nephritis is distinctly rare.



*Skin.*—As complications, erysipelas, furunculosis, impetigo, and pemphigus have been noted; but all are rare.

*Hemorrhages.*—Associated with the hemorrhagic type of the eruption, severe and even fatal hemorrhages may occur from the mucous membranes, and the latter are sometimes seen without the hemorrhagic eruption of the skin. Such manifestations are very uncommon.

*Blood.*—In cases which have been studied early in the stage of incubation, a polymorphonuclear leukocytosis has been observed. This is succeeded by a leukopenia, in which there is a reduction in the lymphocytes, both actual and relative. This condition is marked one or two days before the eruption—sometimes even earlier. The leukopenia continues during the stage of eruption. In this period the usual count is from 2500 to 8000. A decided leukocytosis during this time or later points to a complication.

*Other Infectious Diseases.*—Measles in institutions is often complicated by diphtheria, sometimes by dysentery. Measles apparently lowers the resistance to other diseases. Scarlet fever or varicella occasionally occurs during measles, though it is rare that the two eruptions are exactly simultaneous. Epidemics of measles and whooping cough frequently occur together or follow each other. The relation of measles to tuberculosis seems to be particularly close. In some cases active tuberculosis follows directly in the wake of measles, which seems to furnish, especially in the lungs, conditions which are favorable for the activation of a latent process. An attack of measles in a child with latent tuberculosis should, therefore, always be looked upon with apprehension.

**Diagnosis.**—Measles runs a more regular and typical course than the other exanthemata. Except in the period of invasion there is usually little reason for confusing it with other diseases. Here the presence of Koplik's spots will prove of the utmost value. Indeed, in the differentiation of measles from other diseases they are the symptom chiefly to be relied upon, since they are pathognomonic. The prodromal eruption of smallpox at times appears like that of measles but the course of events soon distinguishes between the two.

The eruption resulting from serum injections may closely simulate that of measles. With the former, however, there are often to be found urticarial wheals somewhere upon the body and there may be joint swellings or pain, and adenitis of the superficial nodes.

Other causes of morbilliform eruptions are drugs, exanthem subitum and rubella. Koplik's spots may be of little help if the case is seen late. The coryza is a very helpful symptom. Rubella is distinguished by its very short course, absence of coryza and the characteristic swelling of the occipital lymph nodes. Scarlet fever occasionally causes diagnostic difficulties.

In the presence of pseudomembranous inflammations of the throat a differentiation from diphtheria can be made only by culture.

**Prognosis.**—This depends upon the age and previous condition of the patient, the character of the epidemic, and the season of the year. Except in children under three years of age, the deaths from measles are few; but in institutions containing young children, no epidemic disease is more fatal.

The general mortality of the disease is from 4 to 6 per cent; but in epidemics



in institutions for young children it has, in our experience, ranged from 15 to 35 per cent. The following table gives the figures of an epidemic in one institution:

TABLE XLVII  
AGE AND MORTALITY IN A MEASLES EPIDEMIC

Age	Cases	Mortality, Per Cent
Six to twelve months.....	42	33
One to two years.....	51	50
Two to three years.....	27	30
Three to four years.....	20	14

The lower mortality seen in the first as compared with the second year is in agreement with the findings of others, that the immunity of the newly born diminishes gradually and that many of the cases in young infants are mild, resembling the abortive or “modified” measles seen in patients who have received prophylactic treatment.

In any single case the important symptoms for prognosis are the temperature and the character of the eruption. An initial temperature above 103° F., or one which remains high until the eruption appears, is a bad symptom. So also is one which rises after a full eruption, or which does not fall as the rash fades. The following table shows the highest temperature and mortality in 161 hospital cases:

TABLE XLVIII  
RELATION BETWEEN TEMPERATURE AND MORTALITY IN MEASLES

Highest Temperature	Cases	Mortality, Per Cent
Not over 102° F. ....	6	0
102° to 103.5° F. ....	14	7
104° to 104.5° F. ....	49	16
105° to 105.5° F. ....	65	40
106° F. and over.....	27	80

A favorable eruption is one of a bright color, covering the body, remaining discrete, and spreading gradually. It is unfavorable for the eruption to appear late, to be very faint, scanty, or intensely hemorrhagic, or to recede suddenly, as this is usually due to a feeble circulation.

Of 51 fatal cases, the cause of death was bronchopneumonia in 45, dysentery in 4, and membranous laryngitis in 2. More than half the deaths occurred during the second week, the earliest being upon the fifth day of the disease.

The ultimate result of an attack of measles may not be evident for some time. Cases in which the temperature persists for two or three weeks without assignable cause after the disease is apparently over should be watched with the greatest solicitude. The explanation of this is most frequently to be found in the lungs, although the physical signs are often obscure. The condition may be either pneumonia or pulmonary tuberculosis. Even though the attack of measles may not have



been in itself severe, seeds are often sown, the full fruits of which are not seen until long afterward. Chronic glandular enlargements which may or may not be tuberculous, chronic bronchitis, chronic laryngitis, and subacute or chronic nasal catarrh, all may be seen as sequels but are infrequent.

**Prophylaxis.**—Measles is often regarded by the laity as so mild a disease that its prevention is thought to be of little importance, and no effort is made to limit its extension. The great probability that every person at some time in his life will have the disease is no justification of unnecessary exposure. Although in older children measles is usually mild, this is not so during the first two years of life. Special care should be taken to protect infants, delicate children, those with a strong tendency to pulmonary disease or those with latent tuberculosis. In institutions it is of the utmost importance to secure prompt and complete isolation of the first case which appears.

In an institution, the ward or cottage from which a case has been removed should be quarantined for at least eighteen days after the appearance of the last case, and absolute security cannot be said to exist until the end of three weeks. The same rule should be applied in private families where children who have been exposed should be quarantined apart from the patient, but not sent away. In ordinary circumstances the quarantine of a case of measles should be placed at two weeks, or one week from the beginning of the eruption. It should be continued longer if there is otitis or a nasal discharge.

The sick room should be thoroughly cleansed and aired for forty-eight hours, after which it may be considered safe for occupancy. Children should be kept from all schools while the disease is in their homes, chiefly because they are otherwise likely to spread the disease while suffering from its early symptoms.

**Protective Inoculation.**—Since it was first advised by Nicolle and Conseil, prevention of measles by the injection of serum from convalescent patients has been practiced on a large scale on the Continent of Europe and in America. Blood is withdrawn from healthy patients who have a negative Wassermann reaction, two or three weeks after an attack of measles. The serum is separated and injected intramuscularly in amounts of from 5 to 10 c.c., as early as possible after exposure. If given within three days an attack of measles is usually prevented. After that time the chances of actually warding off the disease diminish rapidly from day to day, though the course of the ensuing attack may be modified even when the injection has been given as late as seven days after exposure. In so-called modified measles, the eruption may be scanty and atypical, there may be inconsequential catarrhal symptoms, and no fever whatever. The period of incubation is sometimes lengthened; we have seen it twenty-five days. Injection of serum or whole blood from an adult who has had measles in childhood will prevent or modify measles quite as effectively as convalescent serum, but larger doses must be used. Children under five years of age should be given 30 c.c. of whole blood or 15 c.c. of serum intramuscularly. For older children double these quantities should be used. The human placental extract of McKhann and Chu, now available commercially, is more potent than either of the preceding agents; 2 c.c. administered before the fourth day after exposure will usually prevent the disease, and the same amount will often protect when given as late as the sixth or seventh day. It may cause



transient febrile reactions. The immunity afforded by an attack of modified measles is probably comparable to that conveyed by a full-blown attack of the disease, whereas the protection afforded by effective preventive inoculation lasts but three or four weeks.

Protective inoculation is of great value in arresting the spread of measles. It also enables one to shield young infants, who bear measles badly, children with other serious diseases, and tuberculous patients, with whom measles is especially to be dreaded.

**Treatment.**—Measles is a self-limited disease. The indications are therefore to treat serious symptoms as they arise, and to prevent complications.

While the bed should be screened to protect the sensitive eyes of the patient it is not desirable to exclude sunlight from the sick room. Every child with measles should be put to bed and kept there with light covering during the entire febrile period. The food should be light, fluid, and given at regular intervals. If the conjunctivitis is severe, iced cloths should be applied to the eyes, which should be kept clean by the frequent use of a solution of boric acid, the lids being prevented from adhering by the application of petrolatum or some simple ointment. The intense itching and burning of the skin may be relieved by inunctions of plain or carbolized petrolatum, or by bathing with a solution of bicarbonate of soda or calamine lotion. The cough, when distressing, may be allayed by small doses of opium, either in the form of codeine or paregoric. The restlessness, headache, and the general discomfort which accompany the height of the fever may be relieved by aspirin.

The important indications to be met in the severe cases are very high temperature, circulatory depression, and nervous symptoms—dullness, stupor, sometimes coma or convulsions. In some of the cases there is, in addition, dyspnea and cyanosis, showing severe acute pulmonary congestion. For the nervous symptoms and high temperature, nothing is so reliable as the cold bath or pack and the nearly continuous use of ice to the head. We do not think there is any evidence that the use of cold increases the liability to pneumonia; but cold extremities, feeble pulse, and cyanosis, when associated with high temperature, call for the hot mustard pack, although ice should still be applied to the head. The indications for stimulants and the methods of using them are the same as in pneumonia, which is usually present in cases requiring them.

To diminish the chances of pneumonia, it is necessary that every patient should be kept in bed during the attack, and care exercised to avoid exposure. But still more important is it in hospitals and institutions where most of the cases of pneumonia occur, to allow the patients plenty of air space, never crowding them together in small wards. If in hospitals, children with measles should be placed in separate cubicles if possible. They should at least be separated by sheets hanging between the beds, otherwise there is great danger of cross-infections, particularly pneumonia. Cases complicated by pneumonia should be isolated.

The danger of diphtheria as a complication may be greatly lessened if during epidemics of measles in institutions every case receives an immunizing dose of diphtheria antitoxin.



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## CHAPTER CXX

### RUBELLA

Rubella (German measles) is a contagious eruptive fever which is rarely seen except when prevailing epidemically. It is characterized by a short period of invasion, with mild, indefinite symptoms, usually lasting but a few hours, and by an eruption which is generally well marked but of variable appearance. The constitutional symptoms are very mild, and the disease rarely proves fatal, not often being even serious.

Rubella is not a simple affection of the skin; it prevails independently either of measles or of scarlet fever; its incubation, eruption, invasion, and symptoms differ materially from those of both these diseases; it attacks indiscriminately and with equal severity those who have had measles and scarlet fever and those who have not, nor does it protect in any degree against either of them; it never produces anything but rubella in those exposed to its contagion; it occurs but once in the same individual.

**Etiology.**—Rubella is beyond question contagious, but is decidedly less so than either measles or scarlet fever, so that some observers have doubted its contagion altogether. It can be communicated at any time during its course, but especially during the early stage. Epidemics usually prevail in the winter or spring. As in the other eruptive fevers, a striking immunity is seen in infants under six months old; but, with this exception, all ages are liable to the disease.

The incubation of rubella varies considerably; the usual period is from fourteen to twenty-one days.

**Symptoms.**—*Invasion.*—This is rarely more than half a day, and generally the rash is the first thing to attract attention. In a few cases there are mild catarrhal symptoms, with general malaise and slight fever. Rarely there may be vomiting, epistaxis, rigors, headache, or dizziness.

*Eruption.*—This generally appears first upon the face, and spreads rapidly to the whole body, the lower extremities being last covered. Less than a day is usually required for its full development. Exceptionally the eruption comes first upon the chest and back, and sometimes nearly the whole body is covered almost at once. The rash is occasionally observed in the roof of the mouth before it is visible on the face. In a considerable number of cases the entire body is not covered; but the rash is more constantly seen upon the face than upon other parts of the body.

Its character is subject to considerable variation. The eruption is most frequently composed of very small maculopapules; they are of a pale-red color, and vary in size from a pin's head to a pea. The spots are usually discrete, but may cover the greater part of the body. On the face it is frequently confluent, and often appears here as large, irregular blotches of a red color. From this description the rash will be seen to resemble that of measles more than that of any other



disease. Very often, however, there is a fairly uniform red blush which bears a close resemblance to the rash of scarlet fever; but even in such cases there will nearly always be found upon some part of the body, usually the wrists, fingers, or forehead, some typical maculopapules. The color of the eruption is sometimes dark red, and rarely it is hemorrhagic. The degree of elevation above the surface is also variable; sometimes this is so marked as to give to the skin a "shotty" feel, while in others the elevation is scarcely perceptible. The duration of the eruption is usually three days. Occasionally it lasts only two days, and it may last but one. It fades in the order of its appearance, and more rapidly than the eruption of measles. A slight brown pigmentation of the skin sometimes remains for a few days after the rash.

The highest temperature is coincident with the full eruption; this does not usually exceed  $101^{\circ}$  F., and often it is only  $100^{\circ}$  F. As a rule, the temperature continues but two days, falling as the eruption fades. Rarely more severe cases are seen in which the fever lasts for two or three days, being  $101^{\circ}$  or  $102^{\circ}$  F. during the invasion, and rising to  $103^{\circ}$  F. or more during the full eruption. The other symptoms are in most cases even less marked than the fever. Occasionally catarrhal symptoms resembling a mild attack of measles are present, or a sore throat suggesting mild scarlet fever; but more frequently all these symptoms are absent. The eruption is usually out of all proportion to the other signs of disease.

Swelling of the occipital lymph nodes is one of the most constant features of rubella. In most epidemics it is seen in nearly all cases; but as a symptom for differential diagnosis it is not of great importance, as it is not uncommon in measles and scarlet fever. The glandular swelling is most marked at the height of the disease; it is never very great, and subsides slowly without suppuration. The spleen may be enlarged. Swelling and itching of the skin are usually present and sometimes marked. There is no leukocytosis in this disease.

There may be a few punctate red spots on the soft palate or diffuse mottling, but nothing characteristic. The buccal mucous membrane is normal.

*Desquamation.*—This is exceedingly variable. It is sometimes entirely wanting; writers who have observed some fairly typical epidemics have stated that it did not occur. In most cases, however, some desquamation is present, though it may be so slight as to be discovered only by a close examination. It is usually in the form of fine scales over the body and extremities.

**Prognosis.**—There are few diseases so free from danger as rubella. Complications and sequelae are very seldom seen, and when present are usually of the mildest character.

**Diagnosis.**—The principal interest attaching to rubella is in its diagnosis. This is a matter of extreme difficulty, and in sporadic cases it is often impossible. The characteristic thing about the disease is a well-marked eruption with very few other symptoms. Cases so closely resemble mild scarlet fever that the differentiation must be made by the circumstances in which the disease occurs, especially a prevailing epidemic. Scarlet fever with a low temperature and abundant rash should always be regarded with suspicion; also an abundant rash with little or no desquamation. The longer period of incubation in rubella is often of much assistance. Koplik's sign furnishes a valuable means of distinguishing measles from



rubella. The difficulties in diagnosis can be appreciated only by one who has seen epidemics of measles and scarlet fever in institutions, and has watched the exceedingly mild course of undoubted cases of these diseases which have there occurred. The characteristic glandular enlargement is of great assistance in differentiating rubella from drug rashes and other so-called toxic eruptions.

It is always hazardous to make the diagnosis of rubella unless the disease is prevailing epidemically. Sporadic cases in which this diagnosis is made are, we believe, usually either examples of a toxic, noninfectious eruption or instances of mild measles or scarlet fever. The first cases of rubella in an epidemic are usually overlooked. The continued absence in succeeding cases of the characteristic symptoms and complications of measles or scarlet fever should suggest to the physician that he is probably dealing with rubella.

**Treatment.**—None whatever is required for the disease excepting isolation, which should be complete until the diagnosis is determined; after this it is hardly necessary.

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## CHAPTER CXXI

### EXANTHEM SUBITUM

This disease was well described by Zahorsky in 1913 under the name of *roseola infantum*, and was recognized by him as a distinct entity. It was given the appropriate name of *exanthem subitum* by Veeder and Hempelmann. Nothing is known regarding the infective agent, the lesions produced or the method of propagation. It appears to be very slightly contagious, for not more than one child in a household is attacked at the same time. The disease usually affects children under three years of age. Only a few cases have been reported in patients older than this.

The onset is acute, with fever which may reach 103° or 104° F. There may be convulsions. Catarrhal symptoms are usually absent. There may be drowsiness or some irritability but a striking feature of the disease is that in spite of the marked elevation of temperature the children do not seem ill. There is a leukopenia (3000 to 7000) and a relative increase in the lymphocytes (70 to 90 per cent). The fever stays high for three or four days and then falls almost by crisis. There then appears rapidly a macular or maculopapular, pinkish or reddish eruption which is widely disseminated over the body and to a less extent on the extremities and the lower part of the face. The eruption occasionally appears a few hours before the temperature falls. The eruption is much like that of measles in appearance. It begins to fade in a few hours and disappears entirely in two or three days. Except for the slight indisposition consequent upon the febrile reaction, the child is quite well after defervescence. There are no complications and no sequelae.

The interest in the disease is chiefly in the diagnosis. It is distinguished from measles, with which its rash is most likely to be confused, by the absence of Koplik's spots, lacrimation and coryza, but especially by the rapid subsidence of the fever with the outbreak of the eruption. From rubella it is distinguished by the height and continuance of the fever. It can hardly be confused with other exanthemata. The treatment is purely symptomatic.

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## CHAPTER CXXII

### VARICELLA

Varicella (chickenpox) is an acute, contagious disease, characterized by a cutaneous eruption of papules and vesicles and by mild constitutional symptoms, serious complications and sequelae being very rare.

**Etiology.**—The disease is due to a filtrable virus which is present in the vesicles and in the blood also. Scratching the skin at the height of the disease will produce a typical vesicle at the spot. The view, first advanced by Bókay and supported by Le Feuvre and Netter, that the viruses of varicella and of herpes zoster are identical, is based on epidemiological evidence. It cannot be stated positively whether the instances of supposed development of varicella after exposure to zoster are to be accepted or explained on the basis of errors in diagnosis or accidental infections. While we are not inclined to accept this unitarian view, it is clear that no definite decision is possible until more accurate methods are available for the study of viruses. Varicella is contracted by exposure to another case, rarely through the medium of a third person. It affects children of all ages, one attack being as a rule protective. The newly born probably possess an immunity, for the disease is rare during the first two or three months of life. It has been reported as early as the eleventh day, however. Varicella is very contagious, resembling measles in this respect. The period of incubation is quite uniformly from fourteen to sixteen days. Brokman and Mayzner have reported the presence of a positive skin reaction to heated varicella virus, which develops during the incubation period; if their observations can be confirmed, the test should prove useful in the control of epidemics.

**Symptoms.**—Slight fever and general indisposition may be noticed for twenty-four hours before the appearance of the eruption, but in most cases the eruption is the first symptom. It usually appears first upon the face or trunk, as small, red, widely scattered papules, which itch considerably. The papules in most cases come in crops, new ones continuing to appear for three or four days, even upon the same part of the body. The earlier ones have generally begun to dry up by the time the later ones appear, so that all stages of the eruption may be present at one time in the same region, this being one of the diagnostic features. The papules are at first very small, but gradually increase in size, and are surrounded by an areola from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch in width. Many of them go no further than this stage, but the majority become vesicular. The vesicles are usually flat, and vary a good deal in size—the largest being about  $\frac{1}{4}$  inch in diameter. The process of drying up generally begins at the center; this causes a slight depression, giving the vesicle a somewhat umbilicated appearance. The areola is most distinct at the time of the fully formed vesicle, and fades as the latter dries. Crusts now form, which fall off in from five to twenty days, depending upon the depth to which the



skin has been involved. In the majority of cases no mark is left, but after the most severe attacks, when the true skin has been involved, scars remain, and occasionally there is quite deep pitting. Such marks are few in number, and are most likely to occur upon the face.

Sometimes, especially upon hands and feet, the vesicle appears without having been preceded by a papule; often there is no areola, and the vesicle resembles a drop of water upon healthy skin. Pus may develop in consequence of irritation or infection, the result of scratching, or in children who are poorly nourished. Under these circumstances deeper ulceration may occur, lasting for weeks. In rare cases there may be a necrotic inflammation about the site of the pock, a condition to which is sometimes given the name *varicella gangrenosa*.

The pocks are usually most abundant over the back and shoulders. In mild cases only twenty or thirty may be found upon the entire body, but in severe cases the skin in certain regions may be nearly covered. The eruption is never confluent. The pocks are usually seen on the hairy scalp, and often on the mucous membrane of the mouth or pharynx—a point of some diagnostic value. In the latter situation the appearance is first as a tiny vesicle, and later as a superficial ulcer resembling that of herpetic stomatitis. Lesions are occasionally found on the palpebral conjunctiva, which cause considerable discomfort. Marfan and Hallé have described cases of varicella of the larynx. Croupy symptoms were present, and in one case which proved fatal from pneumonia a tiny ulcer was found on the vocal cords.

The temperature is highest when the eruption is most rapidly appearing, this usually being the second or third day. In an average case it reaches only 101° or 102° F., and lasts but two days; in severe cases it may rise to 104° or 105° F., and lasts for four or five days. It falls gradually to normal as the rash fades. The other symptoms are mild and not characteristic. There is no leukocytosis.

**Complications.**—The most important complication is erysipelas, which develops about the pocks, particularly when they are deep and attended with some ulceration. Boils, subcutaneous abscesses and suppurative adenitis may result from lowered resistance to secondary infection. In a few instances gangrene has occurred. Nephritis is very infrequent, but a number of cases have been recorded. It may occur at the height of the disease, but more often at a later period, like the nephritis of scarlet fever. Varicella is quite frequently complicated by other infectious diseases. We have seen coincident scarlet fever in a number of cases. Severe nervous lesions are said to follow varicella occasionally; the one most frequently reported has been encephalitis. Two such cases have been observed at the Johns Hopkins Hospital. We have seen transverse myelitis develop in a boy of seven after an attack of varicella. We recently saw a case complicated by optic neuritis.

**Diagnosis.**—The diagnosis of varicella is usually easy, provided the following points are kept in mind: first, that the eruption comes out slowly and in crops, so that papules, vesicles, and crusts may be seen upon the skin in close proximity; secondly, that the umbilication is due only to the mode of drying up of the vesicle, which begins at the center; thirdly, the appearance of the pocks upon the mucous membranes, and the history of exposure. It is distinguished from urticaria and “toxic” or drug eruptions by the presence of fever and often by the lesions in



the mouth. The differential diagnosis from smallpox occasionally arises. In smallpox the constitutional symptoms are severe. The lesions are all of uniform age and size. They commonly involve the face; they take five or six days to develop and usually possess a central umbilication. They are much deeper than the lesions of varicella.

Herpes zoster, impetigo, pustular syphilid, hydroa aestivale, urticaria and drug rashes are other possible sources of confusion.

**Treatment.**—Varicella is usually a trivial disease and in the home, unless there are other children who are very young or delicate or in poor condition, quarantine is unnecessary. Quarantine should be enforced in schools and in institutions but is not often successful. Protective inoculation with the blood or serum of convalescent patients has been employed rather extensively. It is effective in a large proportion of cases provided it is practiced soon after exposure. Even if it does not entirely prevent, it alters considerably the character of the disease. The vesicles are very few and the febrile reaction usually nil. The blood should be collected from the convalescent patient not earlier than two weeks after the onset of the disease. Three to five cubic centimeters of serum or double the quantity of whole blood may be injected into the muscles. Vaccination with the contents of vesicles is a less effective prophylactic measure, and has largely been given up. The disease may probably be conveyed as long as the crusts are present, hence isolation should be maintained until they have fallen off. In most cases constitutional symptoms of the disease are so mild as to require no treatment.

Locally, the itching, when annoying, may be allayed by sponging with a 5 per cent solution of bicarbonate of soda or calamine lotion. When the crusts have formed, an ointment containing 2 per cent of ammoniated mercury may be applied. Care is necessary to keep the skin clean, and, in the case of infants, to prevent scratching. In severe cases the urine should be examined.

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## CHAPTER CXXIII

### VACCINIA—VACCINATION

Vaccinia is a febrile disease induced in man by inoculation with the virus of cowpox.

The relation between the virus of cowpox, known as vaccine virus, and that of smallpox is still debated. But the protection against smallpox which is conferred by an attack of vaccinia is one of the best attested facts in medicine. It is the imperative duty of the physician to see to it that every infant is vaccinated.

**Choice of Lymph.**—The lymph now in general use is “glycerinated lymph.” It is obtained from inoculated calves under conditions which are well standardized, so that the opportunity for contamination is minimal.

**Time for Vaccinating.**—In selecting a time for vaccination, the child’s age and general health must be taken into consideration. It is pretty well established that the constitutional disturbance is much less in infancy than in later childhood; and there is, besides, in infancy less chance of accidental infection of the vaccine wound. The incidence of postvaccinal encephalitis, an extremely rare complication in any event, is less in vaccinations performed in infancy. Between the ages of two and six months seems the best general time for vaccination. In delicate infants or in those whose nutrition is a matter of great difficulty, in those who are syphilitic, in those suffering from eczema or any other form of active skin disease, vaccination should be deferred until the child is in good condition, unless he is likely to be exposed to smallpox.

**Technic of Vaccination.**—Either the leg or the arm may be chosen. For girls the lateral aspect of the leg or thigh is ordinarily used, for boys the upper arm over the deltoid insertion. Septic complications are somewhat more common in leg vaccinations. Intradermal inoculation of virus is no longer advised, since the incidence of postvaccinal tetanus was thereby increased. In cleansing the site, vigorous rubbing is to be avoided. The skin should be washed with soap and water, and when alcohol is used it should be allowed to dry thoroughly. Iodine and similar antiseptics may not be employed, because they kill the virus. A drop of the lymph is blown out on the skin and through it a superficial scratch not longer than  $\frac{1}{4}$  inch is made; it is not necessary to draw blood. The lymph is then spread along the scratch with the flat of the needle. The wound should not be covered until dry; it should not be washed for twenty-four hours.

Fixed sterile dressings may be applied with adhesive, but it is preferable to attach a sterile dressing to the clothing. Secondary infections, notably tetanus, are reduced to a minimum thereby. Should the vesicle rupture and discharge serum it should be kept clean and dry by dusting with boric acid. When the local symptoms are at all severe the limb should be kept at rest. Infected vaccination wounds should be treated by general surgical principles.



**Revaccination.**—Regarding the duration of the protective power of a single vaccination, exact statements are impossible. Nearly all writers are agreed that vaccination should be done in infancy, again at puberty, and a third time at about the age of twenty or twenty-five. Many also insist upon revaccination at about the seventh year. It is a safe rule when smallpox is prevalent to vaccinate every person who has not been successfully vaccinated within five years.

**The Normal Course of Vaccinia.**—The course of a first vaccination pock is quite uniform. The wound heals and nothing is noticed until the third to the sixth day, when a red papule makes its appearance. Usually in twenty-four hours more a small vesicle appears which enlarges until the sixth or seventh day, reaching its full development about the ninth day. Its shape and size depend somewhat upon the extent of the scarification (Figs. 150-154). The vesicle is usually from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch in diameter; it is of a pearly-gray color and has a depressed center. During the next two days an areola forms about the vesicle extending from it a variable distance, usually an inch or more into the healthy skin. This areola is normally of a bright red color and accompanied by some induration. Itching and tenderness are present. The reaction is generally at its height about the ninth day. The vesicle usually dries down to a firm, dark crust which remains from one to three weeks and falls off, leaving a bluish scar which fades to white, becoming somewhat mottled. When the process is at its height some constitutional disturbance is usually present; there may be loss of appetite, fretfulness, and general indisposition, and the temperature is usually elevated from one to three degrees. The regional lymph nodes may be tender and swollen. These symptoms generally last for three or four days.

If, in a young infant, the first inoculation is unsuccessful, at least three trials should be made with good virus, and, in the event of further failure, after a year vaccination should be repeated. A failure to inoculate does not mean insusceptibility to smallpox, as is often popularly believed, but most frequently arises from the fact that the virus is inert. We have known one case in which the seventh, and another in which the thirteenth, inoculation was successful after previous failures; occasionally there are seen children who cannot be inoculated at all.

Constitutional symptoms, as previously stated, may be absent in very young infants; but in others there is quite constantly present a fever which runs a fairly regular course. It usually begins on the fourth or fifth day, is remittent in type, and rises gradually, reaching its highest point with the full development of the vesicle. At this time even without the presence of any complications it may touch  $104^{\circ}$  or  $105^{\circ}$  F. We have seen it  $106^{\circ}$  F. The duration of the fever in cases running the usual course is four or five days.

Both the local and the general symptoms are sometimes more severe. This may depend upon the susceptibility of the child, even though the lymph is pure and the vaccination properly done. The original vesicle may be much larger than usual, and small secondary vesicles may form in the neighborhood. In very rare instances a generalized eruption of true vaccinia vesicles occurs with fever and other general symptoms of corresponding severity. Single vesicles may be produced on distant parts of the body as a result of auto-inoculation, usually by scratching. When eczema of the face is present, inoculation may be carried thither. Most of the very





FIG. 150.—FIFTH DAY.



FIG. 151.—SEVENTH DAY.

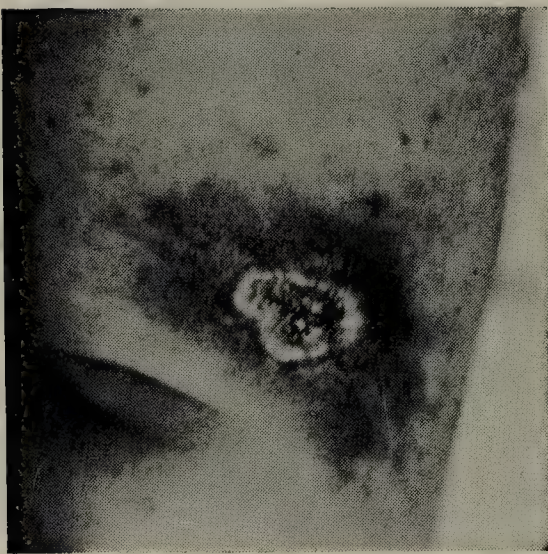


FIG. 152.—NINTH DAY.

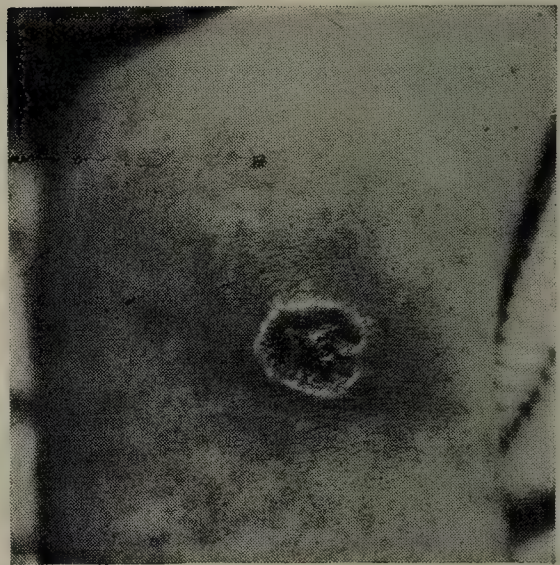


FIG. 153.—ELEVENTH DAY.



FIG. 154.—TENTH DAY.

FIGS. 150-154.—VACCINE VESICLES (TWO-THIRDS NATURAL SIZE).

Figures 150, 151, 152 and 153 show typical appearance of vesicle at the different stages when a very small scarification is made.

Figure 154 shows the effect of a larger scarification with a more intense areola. The amount of inflammation is excessive but not unusual.



sore arms and legs, however, are due to infection from pyogenic bacteria accidentally introduced at the time of vaccination but more often subsequently. In the milder cases the swelling and other evidences of local inflammation are more marked than in a normal vaccination; a drop or two of pus forms beneath the crust, and when the latter comes away an excavation is left which may take two or three weeks to heal. Or, the inflammation may extend more deeply into the connective tissue, to be followed by more extensive suppuration or sloughing, leaving an ugly ulcer an inch or more in diameter which slowly fills by granulation in from five to eight weeks. Sometimes the period of incubation is unduly prolonged, so that the vesicle does not form until the twelfth or fourteenth day, although its subsequent course may be quite normal. In other cases the incubation is very much shorter than usual, and the vesicle may appear as early as the fourth or even the third day.

If individuals are revaccinated who have not lost their immunity from their first vaccination, vaccinia may run an abortive course. The reaction is accelerated, often appearing within twenty-four hours and reaching its height in forty-eight hours. No vesicle is formed, only a papule which subsides rapidly. All degrees are seen between this greatly accelerated reaction and the typical course, depending upon the immunity of the individual.

**Complications and Sequelae.**—A generalized eruption in vaccinia has been mentioned above. Other atypical eruptions are sometimes met with—a generalized roseola, urticaria or, rarely, purpura.

The important complications are pyogenic infection of the wound, tetanus, and encephalitis. The most common local infection is a cellulitis. Erysipelas may develop at any time before the wound is healed. Septicemia may occur. Such infections are usually due to neglect of the wound. They are somewhat more frequent in young infants, and according to Armstrong they are more common in spring vaccinations than those undertaken in the autumn. They are more common in leg vaccinations in ambulant subjects. Syphilis was in years past not infrequently transmitted by vaccination, when human lymph was used.

Tetanus has in rare instances followed vaccination. It may result from contaminated lymph, but more often from accidental contamination of the vaccination sore. Armstrong has collected records of 134 such instances in this country. All occurred in wounds protected by shields or tightly fitting dressings. All were in primary vaccinations. Usually there had been multiple insertions or intradermal insertion of vaccine. The incubation period varied from seventeen to twenty-eight days; the mortality was 75 per cent.

*Postvaccinal encephalitis* is an exceedingly rare complication in this country; less than two dozen cases have been reported up to date. Reports indicate that it is somewhat more common in Europe. It is less frequent in infants than in older subjects. It does not seem to be associated with a severe local reaction or with generalized skin eruptions. The onset is usually from the fifth to the fourteenth day—earlier than that of tetanus. There may be headache, drowsiness, stiff neck and other symptoms of meningeal irritation. In some instances there has been trismus. The spinal fluid is clear and under increased pressure; there may be a mononuclear pleocytosis or no increase in cells. The mortality is 30 to 40 per cent;



those patients who survive usually make complete recoveries, but some exhibit mental deterioration, and perhaps spasticity.

It is not yet clear whether this condition is caused by vaccine virus itself or some unknown virus which flares up when the patient's immunity is impaired by the vaccinia. Whole blood of convalescents from this condition has been used in treatment, but the cases are too few to permit one to judge its value.

*Autovaccination* is not a very uncommon occurrence in uncovered vaccinations. The child scratches the lesion and either inoculates himself elsewhere or some other unvaccinated child with whom he may be playing. Serious consequences may follow if the eye is accidentally inoculated; there is usually perforation of the cornea.

The mortality from vaccination—all complications included—is low. In few countries does it exceed 1 to 2 cases per 100,000 vaccinations. This definite but small mortality is often used as an argument against compulsory vaccination. In some countries, notably Germany and Holland, it appears that vaccination has been so thoroughly enforced that the deaths from vaccination each year outnumber those from smallpox. In the United States, however, the reverse situation prevails and there is every reason to encourage compulsory vaccination.

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## CHAPTER CXXIV

### SMALLPOX

Epidemics of smallpox (*variola*) still break out in this country from time to time, and every year there are several hundred deaths reported, nearly all in unvaccinated individuals; in some years the deaths are numbered by the thousand. Among the unimmunized, children are more likely to contract the disease; a certain degree of immunity seems to develop spontaneously in later life. As is the case with varicella, immunity of the newly born is a very transient phenomenon.

Smallpox shows great variations in its severity. In partially protected individuals, mild, abortive types are seen, known as *varioloid*. Variations in severity may, however, result from alterations in the virulence of the virus itself. Wanklyn gives instances that strongly suggest an increase in virulence during the development of an epidemic.<sup>1</sup> In recent years epidemics of smallpox have been distinctly less severe than those even of forty or fifty years ago.

Smallpox is caused by a filtrable virus, which is closely related to, but apparently not identical with, vaccine virus. Smallpox virus has been converted into vaccine virus by passage through a cow, but the reverse change has not been accomplished, which suggests that vaccine virus is a mutation rather than an attenuated virus; the question, however, is still unsettled. The virus of smallpox is present in the blood and in the skin lesions of the patient. The disease has been transmitted to apes by inoculation of whole blood. In the local lesions there are regularly found small cytoplasmic inclusions, the so-called *Guarnieri's bodies*.

**Pathology.**—The lesions found at autopsy are often widespread. Staphylococci and streptococci are commonly present in the pustules, but the typical suppuration does not depend on their presence, for sometimes no secondary invaders are demonstrable. There may be, in addition to the pustular lesions on the skin and mucous membranes, necrotic changes in the liver, spleen, bone marrow and testis. The buccal and pharyngeal mucosa nearly always shows lesions. Less frequently the conjunctiva and larynx are affected, the latter necessitating intubation or tracheotomy. Pustules may occur in the nose, the esophagus, the bronchi, rectum, vagina or the urethra.

**Symptoms.**—The incubation period is usually between ten and thirteen days, though it may be two or three days shorter or longer. When smallpox is acquired by direct inoculation into the skin the incubation is shorter; a lesion develops on the third day and the fastigium of the disease is reached in seven to nine days.

In adults the infection is regularly biphasic; the onset is with severe constitutional symptoms and often a prodromal rash. These symptoms disappear after a

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<sup>1</sup> For example, an individual at the start of an epidemic contracted what was mistaken for mild influenza with a toxic rash. Some one in contact with him developed an infection with more definite cutaneous symptoms which was regarded as varicella, while others exposed to this second individual developed typical severe attacks of smallpox.



day or two and on the third day the typical skin lesions develop and are accompanied by a second febrile disturbance (fever of maturation). In young children the prodromal constitutional symptoms are likely to be fused with those of the disease proper; the onset is sudden with fever and vomiting. Convulsions are commonly present and, in infants, there may be diarrhea. There is usually little amelioration of the constitutional symptoms. Prodromal rashes are rare in young subjects but the typical skin lesions begin earlier, usually within forty-eight hours.

The eruption of smallpox is very characteristic. It develops first on the face and forearms, gradually spreading to the upper arms and trunk and by the third day reaching the lower extremities. Thus, although the lesions may be found in different stages in different parts of the body, in the same region they are all of identical age. The folds of the skin, the axillae and groins are usually spared. The lesions are at first macular, but rapidly become papular, and in twenty-four hours have usually become hard and "shotty." Vesiculation begins a day or two later; it does not begin at the center, but rather toward the periphery of the papule, spreading toward the center. This causes umbilication. By the sixth day the vesicle is well developed, but a red areola remains surrounding it. Its contents, clear at first, soon become turbid and eventually purulent. The pustule usually ruptures about the tenth to the twelfth day, and subsequently dries up with crust formation. Separation of the crusts occurs during the third and fourth weeks and is usually accompanied by severe pruritus. Marked scarring remains at the site of the lesion and is permanent; pigmentation, however, gradually disappears.

The constitutional symptoms are usually very severe in young subjects. The tongue is heavily coated, and the breath is foul. Nervous symptoms are often extreme, especially in young subjects—delirium, great prostration and coma. In cases going on to recovery without complications constitutional symptoms gradually diminish as the skin lesions retrogress.

The blood picture usually shows a leukopenia with a relative mononucleosis early in the disease, to be followed by leukocytosis. The picture, however, is not constant. Anemia is almost invariably present and may be due to bone marrow damage or blood destruction. Enlargement of the spleen is a constant feature and occurs early in the disease.

A number of atypical forms of the disease may occur. The patients may succumb to an overwhelming infection before the development of an eruption, in which case the diagnosis rests on circumstantial evidence alone. In very mild cases, no eruption appears at all. *Confluent smallpox* usually indicates a severe infection and is an unfavorable sign. The eruption may be confluent on the face and not elsewhere. There may be marked edema of the face even when the eruption is not confluent, so much so as to interfere with opening the eyes. There may be nasal obstruction from lesions in the nose.

Even more serious than confluent smallpox are the hemorrhagic types sometimes met with. There may be early purpura (*purpura variolosa*) or the pustular eruption may be hemorrhagic (*variola hemorrhagica*). Both carry an unfavorable prognosis. Hemorrhagic smallpox is often associated with a low temperature and extreme prostration.



*Varioloid* often begins like typical smallpox with marked constitutional symptoms, but the disease melts away on the fourth or fifth day before typical pustules have developed; it may be even shorter. Sometimes an eruption appears only on the face and forearms. The skin lesions are smaller and more superficial; when they do go on to vesiculation, umbilication is often absent. Practically all of these patients recover.

The important complications of smallpox are septic processes starting from the specific lesions. As a result of secondary infection there may be local abscesses, erysipelas, or any of the manifestations of pyemia. Panophthalmitis, sinusitis, otitis or pneumonia may occur. Osteomyelitis is not so very rare. A number of instances of encephalitis have been described.

**Diagnosis.**—In the preëruptive stage smallpox is not likely to be recognized unless an epidemic is present; it may be mistaken for any acute infection. In our experience the two conditions which have most frequently raised the question of smallpox in differential diagnosis are severe varicella, involving the face, and pustular eczema. The differential points between varicella and smallpox are discussed with the former disease. Pustular eczema is often very severe on the face and secondary infection may give rise to some constitutional symptoms; however, these are rarely as marked as in smallpox and there is no enanthem; moreover, the symptoms of eczema usually develop more gradually.

In recent years specific diagnostic reactions have been developed which are distinctly helpful in the diagnosis of smallpox. It was first shown by Tièche that inoculation into the intact skin of the contents of a vesicle would produce an allergic reaction, a zone of redness developing in a few hours and reaching its maximum in about twenty-four hours. A similar reaction can be brought about by the use of heat killed or formolized vaccine virus.

**Treatment.**—The most important part of the general treatment is to force fluids, for young children in particular are likely to become severely dehydrated. Convalescent serum has been used by Teissier with reported benefit. Locally, ice and various antipruritic preparations may give marked relief. Local antiseptics are indicated to check secondary infection of the pustules. Schlesinger recommends concentrated potassium permanganate applied once and followed by repeated applications of a 1.5 per cent solution. Glycerin has also been used both to allay the itching and as a local disinfectant.

Definite statements in regard to prognosis cannot be made because of the great variations seen in different epidemics. Although those in recent years in this country have been mild, there is always the possibility that the disease may break out in a virulent form. In any epidemic, the mortality in young children is likely to be high.

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## CHAPTER CXXV

### PERTUSSIS

Pertussis (whooping cough) is a contagious disease which prevails epidemically and, in all large cities, endemically. Although it may affect persons of any age, it is generally seen in young children. In later childhood pertussis may be ranked as one of the milder infectious diseases, but in infancy it is one of the most fatal. In New York State it causes more deaths than scarlet fever. Pertussis is characterized by a catarrhal affection of the respiratory tract, accompanied by hyperesthesia of the mucous membrane. Its most characteristic manifestation is a peculiar spasmodic cough which occurs in paroxysms, and from which the disease takes its name. The cough is no doubt of reflex origin, from an irritation which has been located by different writers in various parts of the respiratory tract. Its principal complications are interstitial bronchopneumonia and involvement of the central nervous system; it frequently activates pulmonary tuberculosis from a quiescent to an active state.

**Etiology.**—The cause of pertussis is still disputed. The Bordet-Gengou bacillus (*B. pertussis*) is regularly found in the lesions and can be recovered without difficulty from cough plates; unquestionably it plays an important part in the symptomatology of the disease, but opinion is divided as to whether its rôle is primary or secondary. Some authors maintain that the primary agent is a filtrable virus which lowers the resistance of the host, enabling the Bordet bacilli to gain a foothold.

Several investigators have inoculated monkeys with cultures of Bordet bacilli; in some instances an upper respiratory infection was produced, but the results have been conflicting and the failures numerous. Recently Rich, Long and their co-workers inoculated chimpanzees with Bordet organisms and were able in every instance to produce a tracheobronchitis with a paroxysmal cough and an absolute lymphocytosis. These observations would appear to confirm the view that Bordet-Gengou bacilli are solely responsible for the disease, were it not for the fact that these same observers found that a filtrable virus capable of producing coryza in apes was also present in the secretions early in the disease. It is apparent that the question of single or dual etiology is still unsettled. In some cases nuclear inclusions have been found in the alveolar epithelium at autopsy, which would suggest a virus etiology, but these findings are not constant and their significance is not clear at the present time.

The Bordet-Gengou bacillus is a small gram-negative bacillus which closely resembles the influenza bacillus; it can be identified with certainty only in cultures. In the early stages of the disease it can be recovered from cough plates or from cultures of a mucous plug brought up after a paroxysm of coughing. It is found with great uniformity, and complement fixation is usually demonstrable after the second week of the disease. In many cases the influenza bacillus is present in the



sputum; it may appear before the Bordet bacillus. Mallory and Hornor described a lesion which they regarded as pathognomonic (Fig. 155), the bacilli being found among the cilia of the epithelial cells of the trachea and bronchi. This lesion is not confined to pertussis; in pneumonias complicating measles and influenza, Rich has found influenza bacilli similarly located among the cilia.

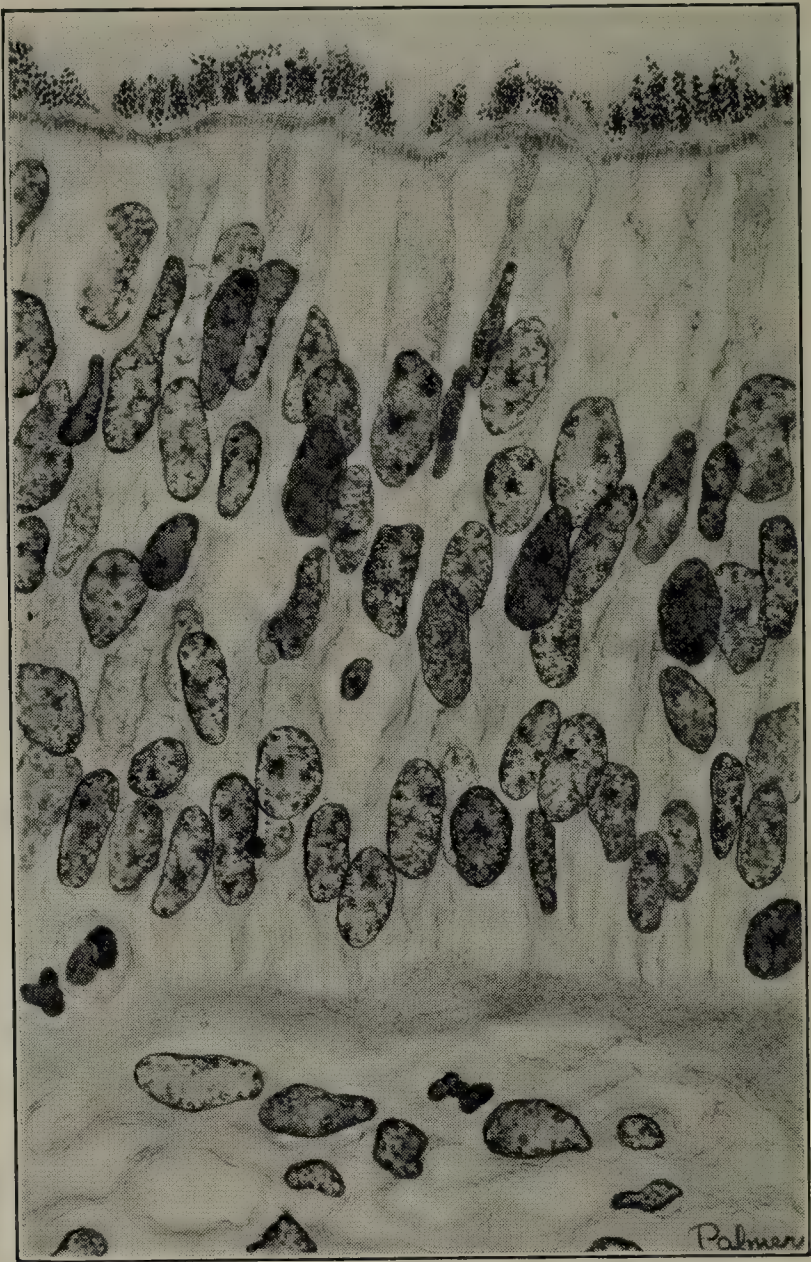


FIG. 155.—BORDET-GENGOU BACILLI AMONG THE CILIA OF THE TRACHEA IN PERTUSSIS.

*Predisposition.*—Fully one-half of the cases of pertussis occur during the first two or three years of life. The following are the statistics of Szabo (Budapest), showing the ages at which the disease was met with in 4591 cases, comprising the records of one clinic for thirty-four years:

<i>Age</i>	<i>Cases</i>
Under one year .....	1,028
One to two years.....	1,008
Two to three years.....	659
Three to four years.....	904
Four to seven years.....	803
Over seven years.....	189

The susceptibility of young infants to pertussis is very great. Many cases are on record in which pertussis has occurred during the first month, and one has come to our notice where a child twelve days old was attacked. There are



records of the disease being acquired on the second day of life. The newly born give little evidence of immunity, although Porak and Durante claimed that young premature infants were relatively insusceptible. In an epidemic observed by them 44 premature infants were exposed, only 4 of whom contracted pertussis, 3 of these in a mild form. The disease is more frequent in the winter and spring than in the summer and autumn. Epidemics of pertussis often occur at the same time with or follow those of measles.

The susceptibility of children to pertussis is comparable with that to measles. Biedert reports that of 401 children exposed during an epidemic in a certain village, 366, or 91 per cent, took the disease. Proximity to a patient seems all that is required to communicate the disease and even close proximity is not necessary. Czerny places the infective distance at about five feet from the patient. The disease seems to be spread chiefly by the droplets diffused by coughing and sneezing.

As a rule one attack protects the individual during his life. The great majority of the reported instances of second attacks are to be explained by mistakes in diagnosis. These may be unavoidable; for it is at times almost impossible to distinguish true pertussis from the paroxysmal cough which occurs as the result of infection with other organisms, notably influenza bacilli.

*Infective Period.*—Pertussis may be communicated from the beginning of the catarrhal stage; it is more contagious at this period than later. There seems little doubt that it is contagious throughout the spasmodic stage, but the infectivity of the disease after the first two or three weeks is slight. The recurrence of the whoop with a fresh cold, after it has once ceased, cannot be considered a relapse nor regarded as contagious. Quarantine is generally required for six weeks.

*Incubation.*—The gradual onset of pertussis renders it impossible in the majority of cases to fix the exact period of incubation. In cases where this could best be determined, it has usually been from five to fourteen days. If, after an exposure, sixteen days pass without the development of a cough, the probabilities are strong that the disease has not been contracted.

*Pathology.*—There is a catarrhal inflammation of varying intensity, which affects the mucous membrane of the larynx, trachea, and bronchi, and sometimes that of the nose and pharynx. The presence of bacilli among the cilia of the trachea and bronchi has already been mentioned. There is often an interstitial infiltration in the bronchi and sometimes in the alveolar walls, even when no exudate is present in the alveoli themselves. If the attack has been severe or protracted, pulmonary emphysema is commonly found. The other lesions are due to complications—to interstitial bronchopneumonia, or lesions in the nervous system. If the child dies during a paroxysm, either with or without convulsions, the brain is found intensely congested and may be the seat of punctate hemorrhages, or even larger extravasations. In rare instances a complicating encephalitis is found.

*Symptoms.*—The symptoms of pertussis are usually divided into three stages—the catarrhal, the spasmodic, and the stage of decline.

*The Catarrhal Stage.*—This continues on the average for about ten days, although cases show considerable variation on this point. The symptoms in the beginning are indistinguishable from those of an ordinary attack of subacute tracheobronchitis, and unless there has been an exposure to pertussis no suspicion



is excited. After five or six days, however, the cough, instead of abating as in an ordinary attack, gradually increases in severity and occurs in paroxysms. At first these are mild, and there are only two or three a day, but they increase in frequency and severity, especially at night, until the typical whoop is heard which marks the beginning of the spasmodic stage. The onset may be with symptoms of a mild coryza indistinguishable from a common cold, and often there is a slight elevation of temperature at this time.

*The Spasmodic Stage.*—In a typical severe paroxysm the child, who can usually foretell it, will often run for support to the lap of the mother or nurse, or seize a chair with both hands. There now occurs a series of explosive coughs, from ten to fifteen in number, coming in such rapid succession that the child cannot get his breath between them; the face becomes a deep-red or purple color; the veins of the face and scalp stand out prominently; the eyes are suffused, and seem almost to start from their sockets; there follows a long-drawn inspiration through the narrowed glottis, producing the crowing sound known as the whoop; then another succession of rapid coughs follows and another whoop. In a single severe paroxysm, which lasts several minutes, the child may whoop half a dozen times; with the final paroxysm a mass of tenacious mucus is usually brought up. In a young child vomiting is almost certain to follow, if food has been recently taken. After a severe attack the child is at times so exhausted as to be hardly able to stand. There is profuse perspiration; his mind is confused, and he may be completely dazed. In infants the attack may result in a degree of asphyxia requiring artificial respiration. Those old enough to describe their sensations tell of a sense of impending suffocation, the suffering from which is almost indescribable. Children with pertussis tend to have slight edema of the face, noticed by puffiness about the eyes; this can be attributed to the frequent paroxysms.

The number of severe paroxysms in twenty-four hours varies, according to the severity of the case, from half a dozen to forty or fifty. There are always many more of a milder form. Paroxysms are often excited by eating, by a cold drink, by exertion, a cold draught, tobacco smoke, or by imitation; they are usually more frequent during the night than the day, and in a close room than in the open air.

In less severe cases no paroxysms of the grade above described may occur, and no typical whoop may be heard throughout the attack; but the paroxysmal nature of the cough which continues until the plug of mucus is expelled, the watery eyes, and the vomiting which follows a paroxysm, stamp the disease as pertussis. In young infants the whoop is frequently not marked. The child sometimes coughs until he is asphyxiated, and yet no whoop occurs. The paroxysms are also modified by intercurrent disease, especially by attacks of pneumonia or severe bronchitis. At such times they usually become less frequent and less typical, and may be absent for several days, returning as the complication subsides. The literature contains a number of reports in which paroxysmal sneezing has been a conspicuous clinical finding.

The seat of the irritation which produces the cough is in the trachea and bronchi. Laryngoscopic examinations have shown catarrhal inflammation, occasionally with punctate hemorrhages in the larynx. More characteristic are the findings in the trachea, where there may be seen a plug of mucus before a coughing



attack, which is subsequently coughed up. There is little doubt that this collection of mucus is the exciting cause of the paroxysm, as it is a familiar clinical fact that the paroxysm continues until this is dislodged.

The average duration of the spasmodic stage is about one month. The spasm increases in intensity for the first two weeks, remains stationary for about a week, and then gradually diminishes in severity. The course and duration of this stage are, however, subject to wide variations. In mild cases it may last only a week; in severe cases, especially in the winter season, it may continue for two or three months, at times almost subsiding, but lighting up again in all its previous severity with every fresh catarrhal attack.

*The Stage of Decline.*—Gradually the severity of the paroxysms abates, the whoop ceases, and the cough resembles more and more that of ordinary bronchitis. This stage usually continues about three weeks, but may be prolonged indefinitely in the winter months. After it has entirely ceased the whoop may return with an attack of bronchitis, and continue for weeks. This is not to be regarded as a true relapse of pertussis. The habit of the paroxysmal cough, once established, tends to recur with every slight bronchitis, often for months afterward.

**Complications.**—*Hemorrhages.*—The hemorrhages of pertussis are mechanical, and depend upon the intense venous congestion which accompanies the paroxysm. Epistaxis is the most frequent variety, and occurs in severe cases, sometimes with almost every severe paroxysm, but it is rarely severe enough to require local treatment. Hemorrhages from the mouth may have their origin either in the pharynx or the bronchi, the blood being brought up by coughing; such hemorrhages are usually small. Conjunctival hemorrhages are less frequent, and are usually slight, although we have seen the entire conjunctiva covered. In one case under our observation there was bleeding from both ears with every severe paroxysm for more than a week. This child had previously suffered from scarlatinal otitis, with perforation of the drum membrane. Small extravasations into the cellular tissue beneath the eyes are occasionally seen, giving an appearance somewhat like an ordinary "black eye." Intracranial hemorrhages are not frequent, but they may be severe enough to produce death. They are usually meningeal; according to their extent and location they may produce various types of paralysis and frequently convulsions, but rarely coma. The extravasations are often small and the symptoms may disappear at the end of a few weeks. More extensive hemorrhages may cause permanent paralysis.

*Respiratory System.*—Otitis media is a frequent complication in infants; it was noted in 7 per cent of the cases observed by Hermann and Bell. The most serious complication of pertussis is interstitial bronchopneumonia; this causes by far the largest number of deaths. It is more frequent in winter and spring than in the summer months, and is especially to be dreaded during infancy. Pneumonia most frequently develops at the height or toward the close of the spasmodic stage. The physical signs present no peculiarities; the cough changes somewhat in character during the pneumonia, and the whoop may not be heard. The prognosis of the pneumonia is bad, because of the condition of the child at the time of its occurrence. As there is always considerable emphysema, the rapidity of breathing is frequently out of proportion to the temperature, which often is only moderately



elevated. If the child escapes the dangers of the acute stage, death may still occur from cachexia, owing to the protracted course which the disease frequently runs.

Vesicular emphysema is invariably present in every case of pertussis which comes to autopsy. A certain amount of it certainly occurs in every severe case. In very severe cases interstitial emphysema is also found. Rupture of the air blebs which form on the surface of the lung may lead to emphysema of the cellular tissue of the mediastinum, and the air may find its way along the great vessels into the neck, and finally into the subcutaneous cellular tissue of the entire body. Cases of general subcutaneous emphysema may terminate fatally. In the great majority of the cases vesicular emphysema is not permanent. Pneumothorax may occur.

*Digestive System.*—Vomiting after coughing spells or after eating is almost a constant feature of pertussis. Gastric tetany may develop as a result of alkalosis caused by loss of the acid gastric secretions; we have seen this repeatedly. During the summer, infants with pertussis often suffer from diarrhea; it may be severe and prolonged, and be the most serious feature of the attack. The nutrition of a patient with whooping cough is often a serious matter. Dehydration or starvation may result in marked loss of weight. Such patients may become extremely emaciated and readily fall a prey to some secondary infection, usually pneumonia.

*Nervous System.*—Several factors may lead to nervous symptoms in pertussis. The possibility of tetany has already been referred to. In other instances asphyxia from paroxysms may lead to convulsions. Cerebral hemorrhage is an infrequent complication; it is accompanied, in severe examples, by continued convulsions and paralysis, usually hemiplegia. In certain instances there can be little doubt that the infectious agent itself produces changes in the nervous system. We have seen a low-grade serous meningitis develop during pertussis with a lymphocytic reaction in the spinal fluid, which cleared up without sequelae. Bertolotti, who performed routine lumbar punctures, found that a mononuclear pleocytosis without symptoms was not infrequent. A more serious but rare complication is encephalitis with widespread cortical degeneration—the so-called progressive cerebral sclerosis (see page 852). We have seen two instances of this condition in Baltimore. The body becomes completely rigid, resembling a decerebrate animal. The mentality is entirely lost and the patient must be fed by gavage. Death occurs after the course of months from cachexia or from some intercurrent infection.

Cerebral complications of pertussis are likely to be met with in severe cases, frequently in those complicated by pneumonia. They always occasion concern, as it may be difficult or impossible to ascertain their underlying cause. The presence of convulsions is an ominous warning, although it does not necessarily mean a bad prognosis. Transient disturbances of sight are not uncommon in severe cases.

Among the other complications of pertussis should be mentioned hernia, prolapsus ani, and ulcer of the frenum of the tongue caused by trauma from the lower teeth during coughing attacks.

*Diagnosis.*—The only constant features of pertussis are the course of the disease and its communicability. In many cases the typical whoop is never heard. There are no symptoms by which a diagnosis can be made in the catarrhal stage; but a cough not accompanied by fever or physical signs, which steadily increases in severity for two weeks in spite of treatment, and which occurs chiefly at night,



is always suspicious. When, in addition, the cough begins to come in paroxysms, accompanied by suffusion of the face and occasionally by vomiting, there can be little doubt even though no whoop is heard. A positive diagnosis in a mild case is often impossible. If there is a history of exposure, if a cough continues from four to six weeks, little influenced by treatment, and if other cases follow, the disease must be pertussis. Without evidence of communicability, however, one may always be in doubt.

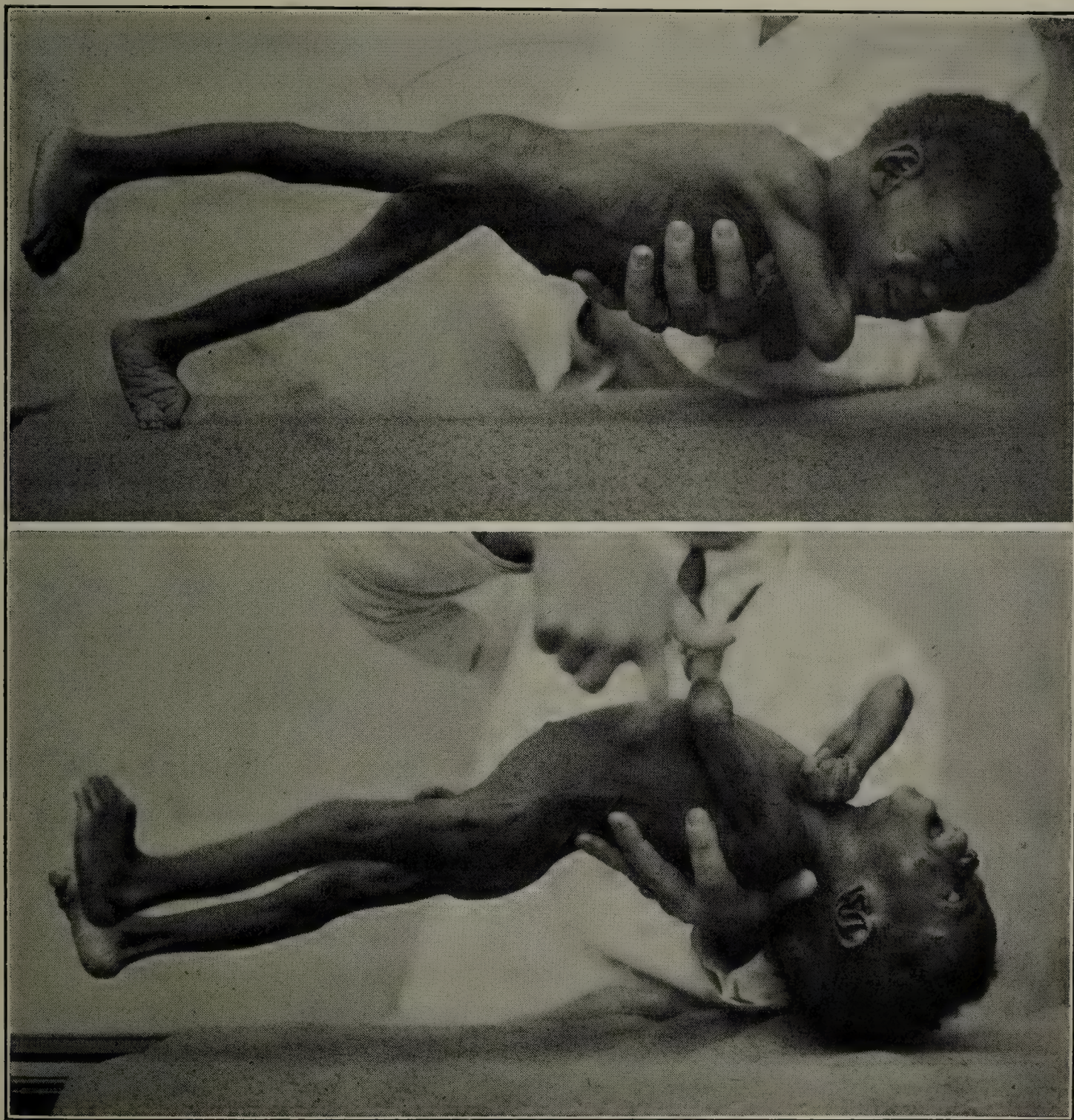


FIG. 156.—PROGRESSIVE CEREBRAL SCLEROSIS FOLLOWING PERTUSSIS.  
Showing rigidity of all muscles; boy one year of age.

Irritation from tuberculous tracheobronchial lymph nodes, or from a foreign body in the air passages, may give rise to a spasmodic cough indistinguishable from that of pertussis. A typical paroxysmal cough may occur in influenza.

The blood examination is often of much assistance in diagnosis. The leukocytosis accompanying pertussis far exceeds that of any other afebrile disease of the respiratory tract. It appears in the early part of the paroxysmal stage, and disappears slowly with improvement. The total count is usually between 15,000 and



30,000, although it may exceed 50,000. There is a great increase in the small lymphocytes at the expense of the polymorphonuclear neutrophils. The lymphocytes may form 60 to 80 per cent of the total leukocytes. Even during bronchopneumonia the lymphocytes may continue to be greatly in excess. When an absolute lymphocytosis is present this is strong confirmatory evidence for the presence of pertussis. This is, however, not a constant finding and is sometimes wanting altogether.

The discovery of Bordet's bacillus in sputum is of great diagnostic value. It is most easily recovered from cough plates. In Denmark complement fixation during convalescence is widely used to confirm the diagnosis in doubtful cases.

**Prognosis.**—The exact mortality of whooping cough is difficult to state. It is probably nearly 50 per cent in infants under three months. During the first year of life it is probably 25 per cent, although it diminishes rapidly after this time. In foundling asylums and hospitals it is particularly to be dreaded; the mortality in such institutions is sometimes as high as 50 per cent. Fully two-thirds of the deaths from pertussis occur during the first year. After the third year it is rare indeed to encounter either a fatal result or serious complications.

The prognosis is affected to some extent by the season; respiratory complications are less frequent in the summer. Not the least important factor in prognosis is the presence of tuberculous infection. Like measles, pertussis often lights up a latent tuberculous focus.

**Prophylaxis.**—Isolation of patients with pertussis should be rigidly enforced. Children with pertussis should never be allowed to attend school, and needless exposure should always be avoided.

Infants should be most carefully guarded from the disease, and also young children who react positively to tuberculin. The infection does not cling to fomites; a thorough cleansing and airing of any room for twenty-four to forty-eight hours is ample. It is as undesirable as it is impossible to confine a child with pertussis to a single room during the attack; all persons for whom exposure would be dangerous should therefore be sent away from the house. Quarantine regulations vary in different communities, from four to six weeks being usually required.

Specific prophylaxis with vaccines made from pertussis bacilli and with convalescent serum has been used. There is an extensive literature on the effects of vaccine treatment, opinion being divided as to whether this procedure possesses any value, either prophylactic or therapeutic. Debré and others have reported successful attempts at prevention by means of convalescent serum; but here too there is conflicting evidence. In our opinion this method has not been employed extensively enough to be properly evaluated.

**Treatment.**—*General Measures.*—Fresh air is important throughout the attack. It is almost invariable that the paroxysms are fewer while patients are out-of-doors, and more frequent when they are in close rooms. Older children with pertussis may go out even in winter except on stormy, raw, or windy days. With infants and delicate children, however, the outdoor treatment in cold weather should be used with the greatest caution. In warm weather or in a mild climate all children should be kept in the open air as much as possible. A change to a warm



climate is desirable when the cough is unduly prolonged, also for delicate children in winter.

Careful feeding and attention to the bowels are matters of importance; with infants particularly, indigestion and abdominal distention have a marked effect in increasing the frequency of the paroxysms. The abdominal support furnished by a snugly fitting band adds materially to the comfort of the patient.

If vomiting is frequent and most of the food taken is rejected, it is advisable to repeat a meal in a short time after the first one has been vomited. The food should be concentrated and small meals given somewhat more frequently than in health. Solid food, such as farina cooked with milk, may be given to infants who vomit repeatedly. Any medication which causes disturbance of the stomach should be omitted.

Something can be done toward diminishing the number of paroxysms by local measures and internal medication. Inhalations of steam impregnated with benzoin, eucalyptol or creosote may loosen the cough and bring some relief. Atropine was widely used in years past; it must be given in full doses if it is to accomplish anything. Nearly all sedatives will control the paroxysms to some extent and will enable the patient to sleep—codeine, chloral and luminal are useful in severe cases; in mild ones no sedative is required. When the paroxysms are frequent and of great severity these mild sedatives are inadequate; in such instances benefit can be obtained from ether given by rectum. The ether is administered as a 25 per cent solution in olive oil, from 3 to 15 c.c. of this being given, depending upon the age of the child. Avertin seems likely to prove useful in the future. Roentgenotherapy to shrink up the bronchial lymph nodes has been recommended, with a view to decreasing the pressure of these structures upon the vagus and recurrent laryngeal nerves. In instances of marked enlargement of these glands, pressure symptoms may play a part in the picture, and improvement may follow such treatment. However, the paroxysmal cough of pertussis results chiefly from local irritation in the trachea and bronchi and in most instances such treatment is ineffective.

In the convalescent stage and even at the height of the disease something can be accomplished in older patients by mental suggestion. The patient should be encouraged to control the paroxysms as far as possible.

Regarding *specific therapy* there is little agreement as to whether anything at all can be accomplished. Vaccines made from stock cultures of Bordet-Gengou bacilli are widely used. They are harmless, but evidence as to their curative value is as yet inconclusive. The same may be said of convalescent serum, which, in our opinion, warrants a further trial. There are a number of reports in the German literature concerning the favorable effects of primary vaccination against smallpox on the course of pertussis. This procedure has received little attention in the United States. In establishing the value of any method of treatment it should be remembered that the number of cases in which the duration of the disease is short is large, and that almost any method of treatment employed after the attack has reached its height will be thought to be beneficial.



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## CHAPTER CXXVI

### ACUTE ANTERIOR POLIOMYELITIS

Acute poliomyelitis (infantile paralysis) is a communicable, infectious disease which prevails both epidemically and sporadically. Formerly poliomyelitis was seen chiefly as a sporadic disease, but since 1905 epidemics have occurred with increasing frequency in various parts of the world. The most extensive epidemic known was that of New York in 1916, in which over 4000 cases were reported in a single month.

**Epidemiology.**—Epidemics thus far observed have almost invariably occurred in the warm months, those in the United States from July to October. Fully four-fifths of the sporadic cases also are seen during these same months.

The simultaneous or successive occurrence of several cases in the same family has long suggested that the disease was directly communicable. This has now been established by animal experiments, and is corroborated by clinical observations. The disease may be communicated by the usual acute paralytic cases even in the incubation period, by mild ambulant abortive cases, or by carriers who may be persons who have recovered from acute attacks, or healthy persons who have never had the disease but have been in close contact with it. How long persons of the last two groups may convey the disease is not known. The virus has been demonstrated in the nasopharyngeal secretions after several months have passed, and it is probable that the nasopharynx is the portal of entry in man. The disease, in most circumstances, is feebly contagious, and only a small proportion of those exposed contract it. As in the case of meningococcus meningitis, it is much more contagious when prevailing epidemically. The transmission by healthy carriers, though exceptional, is undoubtedly the explanation of the occurrence of some of the widely separated cases seen in a community; others of obscure origin may be traced to abortive cases. That the virus of poliomyelitis is carried by insects has not been established. At present we know of no other way of acquiring the disease than by contact with affected persons or with those who serve as carriers.

The period of incubation of the experimental disease in monkeys varies from four to thirty-three days, the average being nine or ten days. In man, also, it is variable, but in most instances the second case in a family has followed the first one within ten days.

**Immunity.**—No age is exempt from poliomyelitis; it is occasionally seen in young infants, and in epidemics a considerable number of adults are always attacked. The greatest incidence is in the second year of life; after the fourth year it becomes relatively infrequent. It seems likely that the majority of adults are immune because they have had the disease in a mild, unrecognized form; the relative insusceptibility of young infants is attributed to antibodies acquired from the mother. By means of inoculation experiments with monkeys, it has been demon-



strated that the blood serum of convalescents and of many adults who give no history of a manifest attack contains antibodies capable of neutralizing poliomyelitis virus.

Second attacks of poliomyelitis are almost unknown; the disease apparently confers a permanent immunity.

**Etiology.**—The specific organism of this disease belongs to the class of filtrable viruses, and it has been shown to be highly neurotropic. With the exception of the nasal mucosa, where it is regularly present, and the lymphoid tissue draining this area—the adenoids, tonsils and other regional nodes—it is found only in the nervous system, particularly in the spinal cord. Only exceptionally has it been recovered from the cerebrospinal fluid. The disease can be transmitted to monkeys regularly only by inoculation with an affected spinal cord, in which the virus persists for months after the acute attack. Such experiments were first successfully carried out by Landsteiner and Popper in 1909; they have since been repeatedly confirmed and extended. Experiments and clinical evidence indicate that the usual path of entrance is the nasal mucous membrane. In monkeys inoculated intracerebrally the virus appears promptly and persists for months in the nasal mucosa, suggesting that this is a path of elimination. Recently Sabin and Olitsky have cultivated the virus *in vitro*, using human embryonic tissue.

**Pathology.**—The gross appearances in acute cases give little idea of the severity of the process, which generally involves the cord throughout its entire length and may involve the medulla, pons, the cerebellum and even the cerebral hemispheres. An acute meningeal reaction is regularly found, involving especially the meninges of the cord and medulla. The pia is infiltrated with small round cells; the changes are most marked about the blood vessels, the walls of which are themselves infiltrated and their lumen narrowed. The vessels entering the nerve structures are affected. Such vascular lesions lead to edema, anemia and, rarely, to thrombosis. Hemorrhages when found are probably due to postmortem manipulation.

The most striking changes are found in the gray matter of the anterior horns, particularly in the cervical and lumbar enlargements. The ganglion cells show marked degenerative changes and in certain parts may disappear altogether, being replaced by phagocytic glial cells. To a lesser degree infiltration with small round cells involves the posterior horns and the white matter of the cord, showing always a perivascular distribution. Similar changes are regularly found in the spinal ganglia. Areas of ganglion cell degeneration and perivascular round cell infiltration may be encountered in the medulla, midbrain, cerebellum and the hemispheres. The changes are especially marked about the nuclei of the cranial nerves, and in the gray matter of the fourth ventricle. Degenerative changes may be found in the nerves corresponding to the degenerated areas in the cord.

In autopsies made in cases of long standing, the affected part of the cord, which is often only one lateral half, is smaller than normal. The general changes are those of a sclerotic character. The ganglion cells of the affected anterior horn have either disappeared altogether, or they are few in number and so shrunken as to be hardly recognizable. The white matter also is smaller than in the sound part of the cord. The lower motor neurons are degenerated quite to the muscles.



The affected muscles are atrophied, and in extreme cases there may be a complete disappearance of muscle fibers, their place being taken by adipose and fibrous tissue. In places where the lesion is less severe the fibers are small. The affected limb is shorter and the bones smaller than upon the sound side. If there has been paralysis of the leg for some years, the fibula may be only a few millimeters in diameter.

**Symptoms.**—Cases of acute poliomyelitis present a wide variety of clinical symptoms depending upon the virulence of the infection, the age of the person attacked, but principally upon the part of the nervous system chiefly implicated in the pathological process. They may be broadly divided into three general groups: the spinal; the bulbospinal; the nonparalytic or so-called abortive cases. A fourth group, the cerebral cases, has often been described. On account of the lack of convincing evidence that this form of encephalitis is due to the virus of poliomyelitis, and on account of the many arguments that can be brought against the identity of the two conditions, it seems wise to omit, at least for the present, the description of a purely cerebral group.

*Spinal Type.*—This group includes the most characteristic form of the disease. In the cases of moderate severity, the onset is abrupt and the symptoms may differ little from those seen in other acute infections. There is usually vomiting, which is not repeated, more frequently constipation than diarrhea, and fever which is generally not over 103° F. Drowsiness, irritability, headache, and prostration are seen in most cases. After the first day more definite symptoms, indicating meningeal involvement, are present—general hyperesthesia, shooting pains in the legs, stiffness of the neck or extremities, pain on motion, and a disinclination to flex the spine. When the patient's shoulders are raised from the bed his head generally falls back limply; and when he is helped up to a sitting position he often prefers to brace his back by leaning on his arms and is unwilling to put his head forward between his knees. The blood shows a moderate polymorphonuclear leukocytosis and the cerebrospinal fluid is generally clear, but may be slightly opalescent. The pressure is somewhat increased. It shows an increased number of cells. The usual number is 40 to 80, but there may be more than 1000. These at first may be chiefly polymorphonuclear, but soon are nearly all lymphocytes. There is an increase of globulin. The paralysis usually appears on the third day after the onset of prodromal symptoms; occasionally it is noticed as early as the first day, or it may be delayed as much as a week. In the milder cases, the fever may not be over 100° or 101° F., and may last only a day, with all the general and local symptoms correspondingly mild, though the resulting paralysis may be extensive. In some cases there is a second rise of temperature ushering in the paralysis, after the patient has been afebrile for several days. Such a febrile course has been illogically termed the "dromedary type."

In the paralytic stage the loss of power sometimes comes on quickly in a few hours, but more often rather gradually, and extends for from two to three days before it is fully developed. The other nervous symptoms usually continue. The posture is in most cases dorsal, with limbs semiflexed, but in some cases with marked meningeal irritation there may be a general flexion of the body with opisthotonos, exactly as in meningococcus meningitis. The same rigidity of the neck and extremities may also be seen. The deep reflexes are not uniform; at first



they may be increased, but are soon lost on the paralyzed side and sometimes also on the sound side. Pain is present on motion, on pressure over nerve trunks, and is sometimes complained of when the patient is quiet. Retention of urine may be so complete as to require catheterization, but in most cases the child is able to void, though with considerable difficulty. The bowels are often constipated. The mind is usually clear, though the child is sensitive to handling, and there may be general hyperesthesia. The duration of the fever is on the average three or four days; it is rare for it to continue longer than a week. The temperature range is generally between 101° and 103° F., and the fall to normal is gradual. Usually the height of the temperature is in proportion to the severity of the infection, but it does not measure the danger of the attack, which depends rather upon what part of the nervous system is involved most seriously.

The description above given is that of the type most frequently met with, but many other forms of the disease are seen which add much to the difficulty of diagnosis. Certain cases present marked cerebral symptoms, chiefly stupor, with few spinal symptoms. After the usual onset, the drowsiness soon develops into deep stupor, which may last for a week or more. These symptoms, with the continuance of the fever, the stiffness of the neck and irregularity of the knee jerk, form a picture which may be confounded with tuberculous meningitis. The paralysis, when it occurs, indicates an involvement of the cord at a high level and affects, besides other parts, one or both arms. Though the symptoms in such cases are most disturbing, the cerebral condition often clears up rapidly and completely.

Other types which may be seen in epidemics are: (1) those in which the symptoms of meningeal irritation are especially marked—extreme muscular and nervous irritability, hyperesthesia and rigidity, a group of symptoms strongly suggesting meningitis; (2) cases in which, with many of the above symptoms, pain is especially prominent; (3) cases in which gastro-intestinal symptoms are particularly marked; both vomiting and diarrhea may last for several days and their prominence may obscure the nervous symptoms.

*Bulbospinal Type.*—The onset and general symptoms differ in no way from the severe cases of the spinal type. It is only after paralysis develops that the characteristic symptoms are seen. This group forms, according to Wickman, about 6 per cent of the epidemic cases. The lesions of the medulla are generally more extensive than one would expect from the symptoms. The symptoms of bulbar paralysis may be unilateral or bilateral. Almost any of the cranial nerves may be involved, altogether the most frequent being the facial. The whole nerve is not always affected. Facial paralysis is usually transient, but may be permanent. Ocular paralysees are next in frequency, the external rectus being oftenest affected, causing internal strabismus. Disturbances of speech are not infrequent, but rarely persist. They are often associated with disturbances of deglutition, which, while not common, may be so severe as to necessitate tube feeding. Hypoglossal paralysis is occasionally seen. With these bulbar symptoms are often associated others, indicating involvement of the upper part of the cord, such as paralysis of the diaphragm, the intercostals, the neck, or the upper extremities. These cases form the most severe and fatal type of acute poliomyelitis met with, and this is the type



that furnishes most of the deaths. The fatal result may be due to respiratory paralysis, to circulatory failure, or to pneumonia.

Acute bulbar paralysis with lesions limited to this part, though formerly described as a separate and distinct disease, is probably only a form of acute poliomyelitis. The paralysis usually affects the muscles of the face, eyes, pharynx, and tongue.

Another rare clinical type is an acute ascending *Landry's paralysis*. After the usual onset, the legs are first involved, then the arms, the neck, and finally the diaphragm and intercostals, with death from respiratory failure. This extension of the paralysis usually occupies three or four days, though it is sometimes more rapid, and death may take place on the second or third day from the beginning of the attack.

*Extent and Distribution of the Paralysis.*—Wickman gives the following grouping of 868 epidemic cases:

	Cases
One or both legs.....	353
Combinations of arms and legs.....	152
Legs and trunk .....	85
One or both arms .....	75
Spinal and cranial nerves.....	34
Ascending paralysis .....	32
Whole body .....	23
Cranial nerves alone .....	22
Descending paralysis .....	13
Arms and trunk.....	10
Trunk alone .....	9
Not given .....	60

The large proportion of cases in which the legs are involved is striking; also the infrequency with which the arms alone are affected, and finally the fact that in the epidemic cases there is a much larger number with widespread paralysis and with cranial nerve involvement. The latter, when occurring sporadically, are generally classed under some other heading than acute poliomyelitis.

The paralysis, when limited to the leg, most frequently affects the anterior tibial group; next, the peroneal, and third, the quadriceps extensor femoris. The paralysis of the upper extremities most often involves the shoulder group, the deltoid being the muscle which usually suffers most severely. Paralysis of the sphincters is very rare, though bladder disturbances are quite common.

Diaphragmatic paralysis occurs when the lesion affects the third to the fifth cervical segments of the cord. It seldom occurs early and may develop quite late in the disease. Though this is always a serious symptom, it may last several days and yet recovery take place. When the diaphragm is paralyzed, all the accessory muscles of respiration are called into action; the respiration is wholly thoracic and the abdominal wall, instead of protruding, is retracted on inspiration.

Paralysis of the intercostals is rare, except in very severe cases, and is usually, but not invariably, fatal. It is seen in association with widespread paralysis of the arms and legs, in the rapidly spreading cases of ascending paralysis, and in the most severe infections. The respiration in intercostal paralysis is purely dia-



phragmatic, which is not always easy to recognize, as it is an exaggeration of the normal infantile type. When both intercostals and diaphragm are involved, we have one of the most distressing conditions seen in the disease, *i.e.*, death by respiratory paralysis. A remarkably vivid picture of this is given in the monograph of Peabody, Draper and Dochez. The mind is usually clear, alert and full of apprehension. Every breath drawn is with severe effort. Sweating is profuse. Cyanosis is usually absent. The struggle may last for several hours before death takes place. Although life may sometimes be prolonged for a considerable time by artificial respiration, there is little hope of recovery.

Paralysis of the abdominal muscles is not common, is usually of one side, but may affect both. It is evident by a great bulging or "ballooning" of part of the abdominal wall in coughing, sneezing, or any forced expiration. It may remain as a permanent paralysis.

*Course of the Disease.*—In those who survive the acute stage, there is a period of days or weeks during which little change is seen. This is followed by spon-

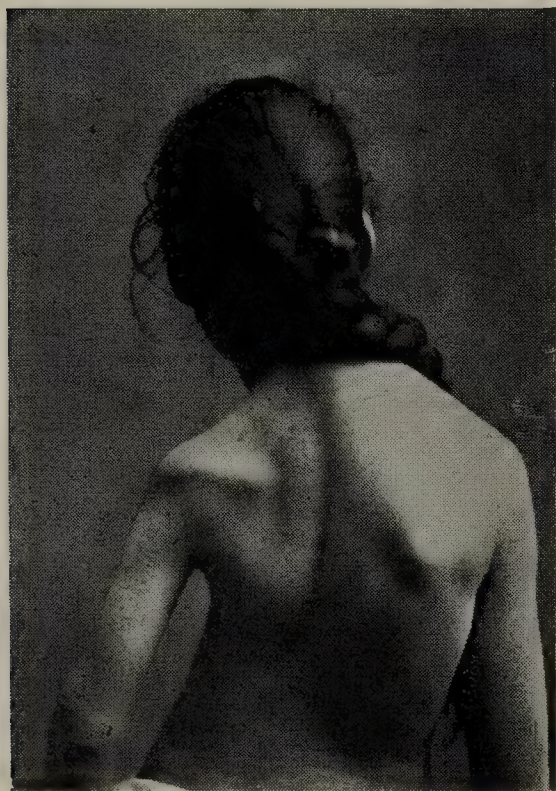


FIG. 157.—OLD CASE OF POLIOMYELITIS OF THE LEFT ARM AND SHOULDER MUSCLES, WITH RESULTING LATERAL CURVATURE OF THE SPINE.

taneous improvement, both in deep reflexes and in muscular power. This usually begins in the muscles last affected, and reaches its limit in from six to twelve months. The paralysis remaining after this time is likely to be permanent, but occasionally improvement continues for two or three years. Except in the early stage, sensory disturbances are absent. By the end of six or eight weeks atrophy is present in the paralyzed muscles. The affected limb is distinctly smaller than its fellow, this being quite apparent even in infants. There is arrested growth in the whole limb, which eventually becomes much smaller and shorter than its fellow. From paralysis of the shoulder and thoracic muscles various chest deformities may result (Fig. 157). Great relaxation of the ligaments at the joints may allow subluxation, especially at the knee and at the shoulder. The circulation in the affected limb is poor; it is often blue and cold.

Very early in the disease the atrophied muscles begin to lose their power to respond to faradism.

In the muscular groups which are likely to be permanently paralyzed, the faradic response may be lost in a week. The muscles in which recovery is to take place often preserve a certain degree of contractility. The response to the galvanic current may be increased for a few months, and then slowly fail as the muscle fibers themselves degenerate, and finally it may disappear altogether. The reaction of degeneration is present in the atrophied muscles, but in them alone.

*Nonparalytic Cases.*—It is now appreciated that abortive attacks are exceedingly common, and probably outnumber the paralytic cases. The prodromal symptoms do not differ in character or in severity from those associated with paralysis. However, since there is nothing characteristic in the clinical symptoms, they pass



unrecognized unless the spinal fluid is examined. In the absence of an epidemic, such cases are almost invariably missed, since lumbar puncture is not likely to be made.

The evidence that these are genuine cases of poliomyelitis rests on their close association with epidemics and the characteristic changes in the spinal fluid. The virus has been demonstrated in the nasal washings of such patients by inoculation of monkeys.

**Diagnosis.**—The recognition of acute poliomyelitis before the occurrence of paralysis is impossible except by lumbar puncture. The characteristic findings in the spinal fluid have been described above. By the time paralysis appears the cells have diminished greatly in number, and the polymorphonuclears have decreased or disappeared, but the globulin may for a time continue to increase. Cases with muscular pains, general hyperesthesia, rigidity and high fever may easily be confounded with meningitis. Bulbar cases with pharyngeal paralysis may readily be mistaken for postdiphtheritic paralysis, especially if there is a history of recent sore throat. An examination of the cerebrospinal fluid is essential for differentiation.

The later manifestations of the spinal type of poliomyelitis are a flaccid type of paralysis with marked atrophy and characteristic electrical reactions, but without sensory symptoms. It may be confounded with multiple neuritis, or the pseudoparalysis of scurvy. Multiple neuritis is rare in children except after diphtheria, and is more gradual in its onset. The type of paralysis and the electrical reactions may be the same as in poliomyelitis, but the paralysis is usually symmetrical, which is rarely the case in poliomyelitis. Certain birth palsies resulting from injuries received during delivery may resemble poliomyelitis when the deltoid or shoulder group of muscles is involved. Without a clear history a differential diagnosis may be impossible.

**Prognosis.**\*—The dangers from poliomyelitis are twofold: that to life during the acute stage, and that to muscles in the form of permanent paralysis and disability. The death rate in the various large epidemics has ranged between 6 and 20 per cent. The danger to life is least in infants and very young children. Sporadic cases are not often fatal. In cases terminating fatally death usually occurs between the fourth and seventh days of the disease. The cause of death is generally bulbar involvement, with respiratory or circulatory failure.

It is impossible to say in any case of advancing paralysis when it will be arrested. It rarely spreads after the seventh day. An important question in prognosis is whether paralysis will be permanent or not. Wickman reports recovery from paralysis in 44 per cent of 530 epidemic cases. This is a larger proportion than most writers give, and much larger than we have ourselves observed. Complete recovery from paralysis in 20 to 25 per cent of the cases is much nearer the average result for American experience. Bulbar cases, if they survive the first ten days, usually make a fairly complete recovery.

Significant symptoms in any given case are the amount of wasting and the electrical reactions. Muscles which soon lose completely their faradic contractility are almost certain to waste rapidly and severely. The best indication of coming improvement is the return of faradic contractility. If this is completely lost for



six months, recovery is very doubtful; if faradic contractility is not lost, great and early improvement in the paralyzed muscles may be confidently predicted. After twelve months but little spontaneous improvement is to be looked for, and after two or three years none at all.

**Treatment.**—All cases of acute poliomyelitis should be isolated. It is not known how long a given case may be infectious. Two weeks' quarantine may be considered a minimum; but during epidemics it is safer to prolong isolation until three weeks from the onset of prodromal symptoms. Discharges from the mouth and nose should be disinfected and destroyed. Persons in contact with active cases should wear face masks or use some cleansing nasal spray or mouth wash. The same cleansing and disinfection of apartments should be practiced as after other infectious diseases.

Convalescent serum given intraspinally, intravenously or intramuscularly has been widely used in the treatment of poliomyelitis in the belief that when given early it would shorten the duration of the fever and mitigate subsequent paralytic symptoms. However, recent large-scale studies, well controlled, have failed to reveal beneficial effects, and it is therefore being generally abandoned for this purpose. The same may be said of pooled adult sera and certain horse sera, despite the fact that, like convalescent serum, they contain neutralizing antibodies for the virus. Serum given after experimental inoculation does not influence the course of the disease in monkeys. Prophylactic injections of neutralizing sera, either from normal adults or convalescents may, however, have some merit. The observations of Stokes and his collaborators suggest that this is the case. Fifteen to 20 c.c of serum or twice that quantity of whole blood may be injected intramuscularly. At present this is the only method of protective inoculation which it seems justifiable to undertake. Active immunization with denatured living virus has not proved successful, and involves a risk of conveying the disease itself.

The treatment during the acute stage of the disease is largely symptomatic; there is no convincing proof that drugs are effective in aborting or preventing paralysis. Absolute rest is essential; even in the mildest non-paralytic cases it should be continued for two full weeks. More than once we have seen patients with an apparently abortive attack in which the initial constitutional symptoms had completely disappeared, suddenly develop evidences of meningeal irritation well on in the second week when allowed to get out of bed. When the evidences of involvement of the central nervous system are definite, the period of rest should be prolonged a week or two after irritative symptoms have disappeared. With spreading paralysis, repeated lumbar puncture may be necessary to relieve increased cerebrospinal fluid pressure. Pain in the affected limbs during the acute stage may be lessened by the application of splints to insure immobilization and also at times by wrapping limbs in cotton. There should be as little handling as possible. It is important to support the limbs, so as to lessen the chance of deformity. Severe pain may require the administration of codeine or morphine. Feeding through a tube is sometimes necessary in bulbar cases for a considerable time, owing to paralysis of the muscles of deglutition. The treatment of respiratory paralysis is almost hopeless. Recovery, when it does occur, may be attributed to failure of the nerve cells to be destroyed, the symptoms depending upon surround-



ing edema. Dehydrating agents, such as magnesium sulphate (2 per cent) or hypertonic saline, injected intravenously, may relieve this edema. We know of an instance in which the injection of 40 per cent sodium chloride solution initiated a most dramatic improvement. Oxygen may afford some symptomatic relief if the paralysis is only partial. With extensive involvement of the respiratory muscles artificial respiration becomes necessary; it is best administered by an apparatus such as that devised by Drinker.

Massage and passive movements may be begun from four to six weeks after the onset, and may be used at first daily and soon twice a day to all affected parts. They should be continued for years. Still more important are active voluntary movements carried out by the patient himself, which should be developed with great care and systematically carried out for an indefinite period. It is really astonishing what such measures when intelligently used can accomplish.

The beneficial effects of electricity have been greatly overestimated. It is rarely useful. Faradism may be used three times a week for such muscles as respond to it; for other muscles galvanism should be employed. The pain and terror which the use of electricity excites in most small children makes its continuance a practical impossibility.

*Mechanical Treatment.*—Mechanical appliances are useful to prevent deformity, also to furnish support to the limb in order to enable the child to walk. By such means many get about with tolerable comfort, for whom locomotion without apparatus is impossible except with crutches. To overcome existing deformities in neglected cases, braces are employed in conjunction with myotomy or tenotomy of the various shortened tendons, excision of portions of elongated tendons, and the production of artificial ankylosis in cases of "flail joints."

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## CHAPTER CXXVII

### EPIDEMIC INFLUENZA

The disease prevails epidemically and pandemically, the greatest in history being the pandemic of 1918, in which the deaths in the United States alone were estimated at over 400,000. In some large communities fully one-third of the population was attacked. The disease is highly contagious, in this respect resembling measles. It is readily communicated directly from person to person; no other mode of conveyance has yet been proven. Its infectivity is apparently greatest in the very early stage, possibly even before the beginning of active symptoms. The deaths from epidemic influenza and its complications are relatively much fewer among children than they are among adults. This is particularly true of infants, who seem to possess a considerable immunity to this infection.

Bacteriological observations made in this disease have thus far been inconclusive. Many investigators still regard Pfeiffer's bacillus as the cause, finding it present in the secretions of the respiratory tract in all severe cases, and explaining the severity and high communicability of the disease as due to greatly increased virulence. They find it in largest numbers and in purest culture at the beginning of the attack; but it is soon mixed with other organisms. The strongest evidence in favor of Pfeiffer's bacillus is the complement fixation reaction, which can usually be demonstrated at the end of the first week. By other observers the essential etiological factor is considered as still undiscovered, the *B. influenzae*, as well as the pneumococcus, the streptococcus and other organisms found, all being regarded as secondary invaders which, while not the cause of the disease, still play an important part in determining the clinical type and complications, and largely affecting its mortality. In 1918 the bacteriological findings reported differed widely. In some localities influenza bacilli were constantly found, while in others streptococci were more regularly present. Complement fixation with the influenza bacillus, when present, usually disappeared within two months, whereas the immunity to the disease is of long duration.

**Symptoms.**—Epidemic influenza has the characteristics of a general rather than a respiratory disease. The onset is abrupt, with chilliness or even a pronounced chill, with prostration, headache, general pains in the muscles of the back, neck and extremities. There may be vomiting and diarrhea. Epistaxis is not uncommon. The face is often deeply suffused and in some cases there are catarrhal symptoms like those seen in the invasion of measles. In others these may be entirely wanting. The appearance of the throat is often characteristic: there is an intense blush involving the entire pharynx, tonsils, uvula and soft palate. Exudate on the tonsils is not uncommon. The amount of general prostration is considerable, even in cases of only moderate severity. Fever is always present but its amount varies greatly. Some of the most severe cases may not have a tem-



perature over  $102^{\circ}$  or  $103^{\circ}$  F., while in others which prove to be less severe, the temperature may quickly rise to  $105^{\circ}$  or  $106^{\circ}$  F. In general, however, the temperature is in proportion to the severity of the attack. The usual duration of the fever in uncomplicated cases is but three or four days, falling gradually to normal. With the fall in temperature all the symptoms rapidly subside except the general prostration, which often continues for a rather surprising period.

As a rule, the leukocyte count is not increased and the percentage of polymorphonuclears is usually less than that of the lymphocytes. A leukopenia is a distinctive feature of severe forms of the disease, though in our experience it is less marked in children than in adults.

Respiratory symptoms are sometimes almost wanting; but in most cases there are cough and signs of bronchitis of the large tubes, or the cough is of the laryngeal or tracheal type.

During epidemics a severe form of catarrhal laryngitis is occasionally encountered which may threaten life. With the laryngoscope one may detect inflammatory edema of the aryteno-epiglottic folds, vocal cords and subglottic mucous membrane. Dyspnea is usually an early symptom; it progresses rapidly and may reach such a degree as to require operation for its relief, though most cases recover without intervention. The diagnosis from diphtheria is sometimes difficult. The prognosis is good unless pneumonia develops. In the most severe cases pneumonia is usually present, develops early and is the cause of death. The type is generally interstitial bronchopneumonia; large areas of consolidation are infrequent. The pulmonary lesions vary greatly, according to the organisms which are present as secondary invaders. The course of the pneumonia is irregular; it may be of the acute congestive type, clearing up rapidly after three or four days; or it may be prolonged and even become chronic. Pleurisy and empyema are not more common than in bronchopneumonia occurring under other conditions. Other complications are rare.

The gastro-intestinal symptoms have nothing characteristic about them. Vomiting is seldom seen except at the onset; but diarrhea may be a prominent feature of the attack. A characteristic feature in the epidemic of 1918 was the prolonged asthenia following an attack; this often persisted several weeks.

**Treatment.**—A great variety of vaccines have been employed, both for prevention and treatment of this disease, but it cannot be said that the value of any vaccine has yet been demonstrated. Treatment therefore resolves itself into that of the patient's symptoms and the complications as they arise. Confinement to bed should be insisted upon for all, even the mildest, cases; after attacks of moderate severity this should be continued for several days after the temperature is normal. The bowels should be kept open, and the general pains relieved by small doses of aspirin or phenacetin and codeine. Food should not be urged, but water given freely. Isolation of the patient should be practiced whenever possible, but unfortunately it can rarely be early enough to prevent the spread of the disease in a household. Children with epidemic influenza do much better when cases are separated, and home treatment rather than hospital treatment should be urged when practicable. The severity of attacks and the frequency of complications are increased by crowding many patients together just as in the case of measles.



Masks worn by nurses or attendants apparently have some value in diminishing the risks of exposure; but since the greatest danger of infection is probably at the very beginning of the attack, the practical usefulness of the mask is not great.

The closure of schools and other places of assembly during an epidemic may be of value in country districts; but in cities such measures are of doubtful efficacy in checking the spread of disease.

**Influenza-like Affections.**—Every winter there are seen greater or lesser epidemics characterized by an upper respiratory infection of variable severity, coupled with marked constitutional symptoms. Such infections are usually designated as influenza, but their relation to the pandemic disease which recurs at longer intervals is not clear, nor is it likely to be settled in the absence of specific diagnostic procedures. Clinically these cases cannot be sharply distinguished from true epidemic influenza on the one hand, and from a common cold with unusually severe constitutional symptoms on the other. We are inclined to believe that many of these minor epidemics are different from true influenza. As is clearly shown by the mortality chart on page 49 the great pandemic of 1918 tended to spare young children; this was borne out by clinical experience at that time. However, in more recent "influenza" epidemics young children have been quite as susceptible as adults.

In an epidemic observed in Baltimore early in 1930 many young children—even infants—were affected; they often exhibited enlarged lymph nodes and a lymphocytic response in the blood, a picture that might well have been mistaken for glandular fever. Relapses were not characteristic of the pandemic of 1918 but are often observed in these minor epidemics; we have seen constitutional symptoms recur two or three times after a free interval of several days.

Infections of this kind are sometimes characterized by digestive symptoms—vomiting and, more particularly, diarrhea; the term "intestinal influenza" is often applied to these. The frequency with which intestinal symptoms occur varies greatly in different epidemics.

Although pulmonary and other complications may occur in these influenza-like infections, these are comparatively rare. The tendency, seen in epidemic influenza, for interstitial pneumonia due to the Pfeiffer bacillus or to hemolytic streptococci to develop, is not pronounced.

It seems quite likely that the variability of the clinical manifestations of influenza is due to the fact that a number of different conditions have been included under this term. Unfortunately this category is an all too convenient one in which to place fevers of undetermined origin; in many instances there exists a pneumonia, a sinus infection, pyelonephritis or some other cause for the symptoms, which has not been recognized.

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## CHAPTER CXXVIII

### INFLUENZA BACILLUS INFECTIONS

In the epidemic of 1892 Pfeiffer isolated and described an organism which he believed to be the cause of influenza, and which now is generally known as the *B. influenzae* or Pfeiffer's bacillus. The correctness of Pfeiffer's views has been questioned by many good observers; but this organism is certainly one of considerable importance in respiratory and other diseases. It is found chiefly in the secretions of the lower respiratory tract; less often in those of the upper tract—the rhinopharynx and discharges from the ears. A feeble and temporary immunity results from infection, and patients are continually liable to recurrent attacks. Like the pneumococcus, the influenza bacillus may be present in the respiratory secretions without producing any symptoms whatever. At other times virulent strains are met with. The organism may quickly find its way into the blood stream, producing an intense septicemia and leading to a severe form of pneumonia, to meningitis, and rarely to endocarditis or suppurative arthritis. Numerous culturally and immunologically different strains are known. Rivers has found that most of the cases of influenza meningitis result from infection with indol-producing strains.

Influenza bacillus infections occur almost exclusively in the cold season. In the respiratory inflammations in which these organisms occur, although they may be found in pure culture, they are usually associated with pneumococci, streptococci, or staphylococci. The influenza bacillus is found in many cases of common cold, but only infrequently is it recovered from inflammations of the paranasal sinuses or the middle ear. It is much more frequently associated with inflammations of the trachea, bronchi, and lungs. In most instances the influenza bacillus attacks the walls of the bronchi and the alveolar septa; the ductuli alveolares are especially implicated. The pneumonia is nearly always of the interstitial bronchopneumonia type. In certain cases resolution is much delayed or is incomplete, and the inflammation may then develop into a chronic interstitial type which continues indefinitely, with later development of fibrosis in the lung of considerable extent, and eventually bronchiectasis. Influenza bacillus infections of the lung are as a rule secondary processes; they are found especially as complications of measles, pertussis and epidemic influenza.

The symptoms of influenza bacillus infection are differentiated with difficulty from those due to the organisms with which it is associated, for it seldom exists alone. It is believed by some to be responsible for the widely fluctuating temperature sometimes obtaining in infections of the upper respiratory tract, and also for the prolonged character of some of the attacks. It is, however, in secondary interstitial bronchopneumonia that it plays its chief and most pernicious rôle. There can be little doubt that it is largely responsible for the protracted course and for



the great tendency to permanent damage in the lungs with fibrosis and bronchiectasis. Even when the infection does not involve the lungs themselves but only the trachea and bronchi, the inflammation thus excited may be very persistent.

There may be, as far as symptoms and physical signs can detect, only a mild attack of laryngotracheitis or tracheobronchitis with few constitutional symptoms but with a paroxysmal cough which is hard to distinguish from pertussis. Such a cough we have seen continue for from four to six weeks with paroxysms so severe as to excite vomiting. We have observed it in families of children who had previously had pertussis. Bordet's bacillus could not be discovered in the sputum but the influenza bacillus was present. There was no lymphocytosis but only a moderate polymorphonuclear leukocytosis. It is not unlikely that many of the reported instances of second attacks of pertussis are of this nature.

Generalized forms of influenza bacillus infection are not common. Every now and then, however, one sees a child with pneumonia who develops general septicemia with this organism.

Suppuration of the large joints, in which this organism was found in the pus in pure culture, we have seen a few times. This usually occurs as a late symptom in septicemia. We have seen it, however, as the first definite local symptom. A boy of eight months after five days of general febrile symptoms developed swelling of an elbow and ankle. When first seen one week later there was considerable prostration, and the influenza bacillus was grown from pus aspirated from both joints. The following day convulsions occurred; the cerebrospinal fluid was turbid and contained the same organism. It was also found in blood culture. Death from meningitis occurred three days later and at autopsy the influenza bacillus was obtained from the brain, lungs and blood. In most instances of influenza meningitis, however, the infection is apparently primary, the nervous symptoms being the first to attract attention.

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References to Influenza Pneumonia are given on pages 480 and 965; to Influenza Meningitis on page 1021.



## CHAPTER CXXIX

### MUMPS

Mumps (epidemic parotitis) is a contagious disease characterized by swelling of the parotid, and sometimes of the other salivary glands, with constitutional symptoms which are usually mild. Both severe complications and a fatal termination are extremely infrequent.

**Etiology.**—The contagious character, regular incubation period and typical course stamp the disease as a specific infection, and evidence points to a filtrable virus as the etiologic factor. By injecting filtered saliva from patients with mumps into the parotid gland of cats, Wollstein induced a disease similar to mumps and was able to transfer the condition from one set of experimental animals to another. More recently, Johnson and Goodpasture introduced saliva from patients with mumps into the parotid duct of monkeys, causing after an incubation period of six or eight days a febrile episode accompanied by enlargement and tenderness of the salivary glands. By injecting emulsions of parotid gland tissue, they were able to transmit the infection through seven generations. Re-inoculation of monkeys which had recovered from the experimental disease failed to produce any specific response.

**Communicability.**—Intimate contact is usually required to communicate the disease. Mumps is contagious from the beginning of the symptoms. Two cases have come under our notice in which the disease was communicated before any swelling was seen. It is impossible to fix with certainty the duration of the infective period. The disease is undoubtedly contagious for a few days after the swelling has begun to subside; and for safety a case should be isolated for three weeks from the beginning of symptoms, or one week after the swelling has essentially disappeared.

**Incubation.**—In 48 collected cases in which the incubation was definitely determined, it was less than fourteen days in only 4 cases, and in 26 of the 48 cases it was between seventeen and twenty days.

**Immunity.**—The susceptibility of children to mumps is much less than with most contagious diseases; only a small proportion of those exposed contract it. The greatest predisposition is between the fourth and fourteenth years. Infants are rarely affected, but whether this is due to natural immunity or to immunity acquired from the mother is not known. The immunity following an attack is usually life-long; second attacks are extremely rare.

**Pathology.**—The precise nature of the changes in the gland is still a matter of dispute, as opportunities for pathological examination are rare. From existing evidence it would appear that the gland substance is first involved, and afterward the surrounding connective tissue. The gland is the seat of an intense hyperemia and edema; the walls of the salivary ducts are swollen, and the ducts are obstructed. While the primary disease does not tend to excite suppuration, pyogenic



organisms may occasionally gain entrance and lead to abscess formation; but this is to be regarded as a rare accidental infection.

In the great proportion of cases the parotids alone are affected, although the same changes are occasionally found in the other salivary glands. There are no other essential lesions of the disease, those which are found depending upon complications.

**Symptoms.**—In the milder cases the local symptoms are the first to attract attention; in those which are more severe there are frequently prodromal symptoms of from twelve to forty-eight hours' duration—anorexia, headache, vomiting, pains in the back and limbs, and fever. The initial temperature in a mild attack is 100° to 101° F.; in a severe one from 102° to 104° F.

Of the local symptoms, the pain usually precedes the swellings; it is increased by movement of the jaws, by pressure, and sometimes by the presence of acid substances in the mouth. It is usually referred to the posterior part of the jaw just below the ear. The swelling may begin simultaneously in both parotids, but more frequently one side is involved a day or two in advance of the other. It usually reaches its maximum on the third day, remains stationary for two or three days, and then subsides gradually. The degree of swelling varies with the severity of the attack. When it is marked, the patient may be so changed in appearance as scarcely to be recognizable. The swelling fills the lateral region of the neck between the jaw and the sternomastoid muscle and extends forward upon the face to the zygomatic arch, so that the center of the tumor is usually the lobe of the ear. The other salivary glands may swell simultaneously with the parotids, or several days later, even after the parotid tumor has disappeared. Occasionally swelling of the submaxillary or sublingual glands occurs before that of the parotid, and in rare instances these may be the only glands affected.

As a rule, the parotid of each side is involved. Of 282 cases both sides were affected in 215. When one side alone is involved, it is the left a little more frequently than the right. The interval between the swelling of the two sides may be a week, or even five or six weeks, but usually it is only two or three days.

The papilla at the mouth of the parotid duct is often reddened; when present this is a helpful diagnostic sign. The salivary secretion is usually much diminished, and the dry mouth causes great discomfort. Exceptionally, distressing salivation occurs.

The constitutional symptoms of mumps usually last from three to five days; the swelling continues about a week longer, but if the case has been a severe one slight swelling may continue for two weeks or more. A spread to the opposite side or to other salivary glands may occur as the disease is subsiding in the gland first affected.

The blood findings in mumps are quite characteristic; an absolute lymphocyte increase is nearly always found. The total leukocytes may be normal, or there may be a leukopenia or a leukocytosis.

**Complications and Sequelae.**—In childhood the complications are few and usually unimportant; but in adolescence they are occasionally serious. Orchitis is exceedingly rare in childhood; of 230 cases observed by Barthez and Rilliet, this was seen in but 10, and only 3 of these cases were in children under fifteen years,



and no case in one under twelve years old. When orchitis occurs it is generally toward the end of the second or the beginning of the third week; it is usually marked by an accession of fever, sometimes by a chill; if severe, nervous symptoms may be present. The body of the testicle and not the epididymis is affected; the gland is swollen and tender. The acute symptoms continue for three or four days, and the entire duration of the attack is about a week, although the testicle is often enlarged for some time afterward, and atrophy of the organ may follow. When orchitis is double, sterility may be the consequence.

In females, congestion and swelling of the breasts have been described; involvement of the ovaries is somewhat more common, but difficult to recognize; although these complications are rare, most of them have been observed in young children. Involvement of other glands has also been described, the thymus, thyroid and lacrimal glands. Pancreatitis as a complication of mumps is discussed elsewhere; we have seen symptoms that could be attributed to this cause very infrequently.

Nephritis has in a few instances followed mumps, sometimes coming on as late as four or five weeks after the attack. Nervous sequelae are more frequent, but even these are rare. We have seen multiple neuritis in a boy of twelve which developed two weeks after a severe attack of mumps. The paralysis was general, lasted for six weeks, and was followed by complete recovery. Other cases have been recorded. Facial paralysis may occur, apparently due to an extension of inflammation from the gland to the seventh nerve. Meningitis is not a rare complication. We have seen several cases accompanied by high fever, delirium, opisthotonos and a clear or slightly turbid cerebrospinal fluid which has contained a striking increase of cells, sometimes more than a thousand per cubic millimeter. The great majority of the cells are mononuclears. The fluid has always been sterile. Recovery has occurred in all instances that we have observed, but fatalities have been reported. The meningeal symptoms may appear before the parotid swelling, in which case, for a time, diagnosis is impossible. Wallgren has described a case in which parotitis was absent. Three brothers were exposed to mumps simultaneously; one of them developed uncomplicated mumps, a second developed parotitis with meningitis, and the third developed only a benign "serous" meningitis.

Pierce has collected an interesting series of 40 cases of deafness following mumps, in which there was no sign of otitis, the symptoms coming on suddenly with vertigo, a staggering gait, and often with vomiting. In most of the cases the deafness was unilateral and the loss of hearing was permanent. The cause assigned was disease of the auditory nerve, the seat of the trouble being in the labyrinth. Toynbee has reported an instance of hemorrhage into the labyrinth. Otitis media is rarely seen.

Suppuration of the parotid gland occurs in about 1 per cent of the cases, and is probably due to accidental infection. Gangrene and sloughing of the parotid were observed twice by Demme in 117 cases; both of these proved fatal. Pneumonia, endocarditis, and pericarditis have been observed as complications of mumps, although all are extremely rare.

**Prognosis.**—In the great proportion of cases mumps is a mild disease, and terminates in complete recovery in a few days. In young children complications are infrequent, and those which occur are rarely severe.



**Diagnosis.**—Mumps is most likely to be confounded with acute swelling of the cervical lymph nodes. In a parotid swelling, the lobe of the ear is near the center of the tumor, which extends backward to the sternomastoid muscle and forward upon the face as far as the zygomatic arch, embracing the angle and ramus of the jaw.

It must not be forgotten that the salivary glands themselves may be the seat of a pyogenic inflammation; sometimes a mass of lymphoid tissue embedded in the gland is the seat of the process.

In acute cervical adenitis the swelling is usually entirely below the ear and behind the jaw, not extending up on the face; the tumor is generally smaller and more circumscribed, and it comes on much more slowly than does that of mumps. When only the submaxillary or sublingual glands are affected, the diagnosis from swollen lymph nodes is sometimes impossible except by the course of the disease. Mumps is characterized by the rapidity with which the swelling occurs. The appearance of the parotid papilla may be of diagnostic assistance. Another characteristic often found in mumps is an inability to take acid foods; lemon juice has been used as a test and may cause pain in the parotid region.

**Treatment.**—The disease is self-limited and the individual symptoms rarely distressing, so that in most cases little treatment is required. While there is fever and much swelling the patient should be kept in bed. If the pain is severe heat or cold should be applied, according to the sensations of the patient. The diet should be liquid, on account of the pain produced by mastication. Mouth washes are sometimes comforting. The general symptoms and complications are to be treated according to the indications presented. Cases of mumps should be quarantined for at least three weeks, although there are records of its being transmitted as late as the fifth week. Hess has obtained most encouraging prophylactic results by the use of convalescent serum.

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## CHAPTER CXXX

### RABIES

Rabies (hydrophobia) is an acute infectious encephalomyelitis; it is communicated by the bite of an infected animal, usually the dog, rarely the cat, skunk, wolf and fox. The disease is readily transmitted to experimental animals by subdural and intraneural inoculation of emulsions of involved nervous tissue. Little is known of the nature of the virus, although Noguchi believed that he had cultivated it. It has been established that it is filtrable.

**Pathology.**—The only gross changes are congestion of the meninges and a few small subpial hemorrhages. Microscopically there is found a diffuse inflammatory process bearing some resemblance to that of acute epidemic encephalitis. A variable amount of meningeal reaction is present. The gray matter is more severely affected than the white matter. The changes are found throughout the central nervous system, but are particularly striking in the nuclei of the pons, the red nucleus and the substantia nigra. The nerve cells show various types of chromatolysis or necrosis; there is active neuronophagia and proliferation of Hortega cells, which become phagocytic. The most characteristic feature is the presence of *Negri bodies*; these are round or oval bodies, 4 to 10 micra in diameter, composed of eosinophile cytoplasm with a small basophilic central body. They are found in the cytoplasm of the nerve cells in practically all cases of rabies, and are particularly abundant in the brain stem. It is generally believed that they are protozoa and represent a stage in the life cycle of the virus.

Apparently the virus reaches the central nervous system by extension along the nerve trunks; the nerves in the region of the wound may show myelin destruction, swelling of the axons and lymphocytic infiltration. There are also inflammatory changes in the salivary glands.

**Symptoms.**—The incubation period is variable; it is usually between three and eight weeks, but it may be as long as a year. When multiple or severe wounds are present and particularly with wounds about the face and head, the incubation period is likely to be short. Approximately 15 to 20 per cent of children bitten by rabid dogs develop rabies, if no prophylactic treatment is given. Once the disease has become manifest, it is invariably fatal.

It is customary to describe three stages of the disease. In the *premonitory stage* there may be pain or numbness at the site of the wound and along the course of the nerves which supply that area. Later there is irritability, drowsiness or inability to sleep and perhaps anxiety or depression. The *second stage* is ushered in by intense excitement, fear and restlessness. The patient may seem to be in terror. There may be delirium. Local twitching and involuntary movements are usually present; often there are general convulsions. Cervical rigidity is common. The temperature may be normal but usually ranges between 102° and 105° F. The



characteristic feature is the violent spasm which affects the muscles of the pharynx and larynx on attempt to take food. These spasms are very painful, so that the patient fears the very sight of water; hence the name of hydrophobia. The spasms may also be precipitated by peripheral stimuli such as a light touch or a loud noise. Vomiting of blood and blood-tinged expectoration is not uncommon. Salivation is sometimes seen. After one to three days the *paralytic stage* supervenes, the spasms cease, and coma and death finally ensue. The entire duration of the disease is seldom more than four or five days.

In rare cases the clinical picture may be one of acute ascending myelitis, and all the symptoms described above may be absent. The diagnosis may be established by the history of a bite by a rabid animal, and the demonstration of Negri bodies, or of the virus in the spinal cord by animal inoculation.

The blood shows a mild leukocytosis. The spinal fluid contains an excess of white cells, mostly polymorphonuclear leukocytes, which may range from 50 to several thousand. Globulin may be normal or slightly increased.

No treatment is of any avail; sedatives should, however, be freely given. Anesthesia may be necessary to control the more violent manifestations. Patients with rabies should be handled cautiously; they have been known to bite attendants or other persons within reach.

**Diagnosis.**—Rabies is usually easy to recognize. Tetanus is practically the only condition with which it may be confused. The history of a bite is characteristic. The incubation period of tetanus is usually shorter than in rabies; it rarely exceeds two weeks. Mental excitement is seldom seen in tetanus. Pharyngeal and laryngeal spasms have been described in that disease, but are rare; in rabies they are constant. Spasms of the body musculature and particularly trismus are characteristic of tetanus. The spinal fluid is normal in tetanus, although the pressure may be increased.

**Prophylaxis.**—If a child is bitten by a rabid animal or one suspected of having rabies, the wound should be cauterized at once with pure nitric or carbolic acid, and a course of Pasteur treatments should be commenced without delay. By these measures it is possible to reduce the incidence of the disease from 15 or 20 per cent to about 1 per cent. The failures are usually due to delay, or to an unusually brief incubation period, which makes immunization impossible before the disease appears. Wounds about the face and head are the least successfully treated. In them the incubation period is likely to be short. Prophylaxis may be ineffectual in facial wounds, even if the incubation period is not unduly short,<sup>1</sup> which suggests that in these cases a larger quantity of virus reaches the central nervous system in a virulent form. Rice advises a course of twenty-one Pasteur treatments for such cases instead of the usual fourteen. It is not known how long the immunity conferred by antirabic vaccination persists, probably not more than one year.

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<sup>1</sup> The following case (reported by Rice) illustrates this point: A six-year-old boy was bitten on the lip by a rabid dog. The wound was cauterized thoroughly within a few hours with nitric acid, and a full course of fourteen Pasteur treatments was given. Ninety-two days after the injury the boy complained of difficulty in swallowing, which increased rapidly. There was marked nervousness and twitching, headache and pain in the neck. The temperature rose rapidly to 105° F.; there was great mental apprehension, followed by extreme excitement and delirium. The limbs became paralyzed, saliva drooled from the mouth. On the fourth day, respiratory distress became marked, the patient grew cyanotic, comatose and died. The spinal fluid showed 16,000 cells, 86 per cent of which were polymorphonuclears. Typical Negri bodies were found at autopsy and the diagnosis was confirmed by animal inoculation.



A question which often arises is whether to immunize a child bitten by a dog, the behavior of which is in other respects normal. There is always the remote possibility that the dog may be incubating the disease and may have virus in his mouth. As a rule one may safely withhold treatment for ten days, the dog being kept under close observation; if the animal then appears normal the question of rabies may be dismissed. Occasionally, however, as when there are severe wounds about the face, it would seem best to proceed with the treatment without waiting for the ten-day period to elapse; if the dog appears normal on the tenth day, the treatment may be discontinued. Treatment should never be withheld if the behavior of the dog is in any way suspicious.

An encephalomyelitis following the Pasteur treatment occurs occasionally; it is seldom fatal. This complication is excessively rare or nonexistent when carbonized (Semple) virus is used; such virus is always to be preferred to the original attenuated living virus of Pasteur.

The incidence of human rabies is directly proportional to the prevalence of the disease in dogs. This menace can be effectively combated by enforced muzzling or antirabic vaccination of dogs.

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## CHAPTER CXXXI

### DIPHTHERIA

Diphtheria is an acute, specific, communicable disease due to the bacillus of Klebs and Löffler. It is usually characterized by the formation of a false membrane upon certain mucous membranes, especially those of the tonsils, pharynx, nose, or larynx. Like other pathogenic bacteria, this organism acts with varying intensity, and may cause inflammation of all degrees of severity, from a mild catarrhal angina to the most serious membranous inflammation; but to all alike the term diphtheria should be applied. In its mild form it may be almost without constitutional symptoms; in its severe form it is attended by great general prostration, cardiac depression, and anemia; it is frequently complicated by pneumonia, and it may be followed by localized or general paralysis.

**Etiology.**—*Mode of Transmission.*—Diphtheria is transmitted usually by direct contact with individuals who harbor the bacilli in the nose and throat. Generally such individuals are suffering from the disease, but virulent bacilli often persist for weeks after the attack is over, sometimes longer, and transmission of the disease is possible for as long as these are present. Recognition of the disease naturally leads to the isolation of the patient, so that it is usually the failure to recognize incipient or mild diphtheria that is responsible for the spread of the disease, especially in schools or camps. Another source of infection has been shown to be the healthy carrier, *i.e.*, a person who harbors virulent bacilli but is himself immune to the disease, and who may never have had diphtheria in a recognized form. The most contagious form of diphtheria is the tonsillar or pharyngeal. The bacilli occur in great numbers in the membranes, the saliva, and the mucous secretions and are spread by coughing, sneezing, talking, kissing, etc. They are not present in the breath alone. The least contagious are those cases in which the membrane is confined to the larynx or lower air passages. Bacilli are not found in the feces and rarely in the urine.

Indirect infection is uncommon, though it may occur through food utensils that have been used by a patient or through swabs or instruments used in treatment. Diphtheria may be carried by a third person who is in close contact with a case, and has not taken sufficient precautions, but this mode of spreading the disease is rare. There are references to the spread of diphtheria by domestic animals, but they hardly bear critical analysis. Occasionally epidemics have been traced to contamination of milk. There is no evidence to show that the disease may be spread by contamination of a water supply. Although it has been shown that the bacilli may retain their virulence for long periods, especially in dry material, infection through fomites is extremely uncommon if it happens at all.

*Epidemiology.*—In most cities diphtheria occurs the year round, with exacerbations in the winter months. Occasionally outbreaks of great severity are ob-



served. In country districts, it is infrequently seen except when it is introduced by an outsider and then it is likely to appear in epidemic form, unless its nature is recognized early.

*Predisposition and Immunity.*—Any infection of the nose and throat predisposes to diphtheria. It is seen especially in children with chronic enlargement of the tonsils and adenoids, and the susceptibility of patients with measles and scarlet fever is striking.

The most important factor that determines individual susceptibility is the presence or absence of antitoxic immunity. It has been demonstrated by means of the Schick test<sup>1</sup> that many persons who have never had a recognized attack of diphtheria possess sufficient antitoxin to render them immune to the disease. This is probably an active immunity brought about by contact with submorbid doses of bacilli; antitoxin demonstrable by the Schick test is present in about 80 per cent of adults. Approximately the same proportion of newly born infants possess antitoxic immunity; this appears to be a passive immunity obtained from the mother through placental transmission, for there is a close parallelism between the antitoxin content of the blood of mothers and their infants. The immunity of infants is gradually lost, so that by the end of the first year only about 60 per cent have negative Schick tests, while at about the third year the number is less than 40 per cent. After the fourth year the percentage of children with negative Schick tests increases, and by the tenth year the adult figure of 80 per cent is reached. These figures represent urban clinical experience. The percentage of older children and adults with a positive Schick test in rural communities is not nearly so high.

The immunity conferred by an attack of serum-treated diphtheria is often transient, persisting in most cases for a few months only; by the end of a year 50 per cent of patients have lost it. The passive immunity conferred by injected antitoxin is still shorter, lasting but a few weeks at the most.

It seems probable that the presence of antitoxin, as demonstrated by the Schick test, is not the only index of immunity to diphtheria. Not infrequently there are seen individuals with a strongly positive Schick test who fail to contract the disease even though they are constantly exposed to it. This suggests that there may be a cellular immunity as well as one dependent on circulating antibodies. In some of the severest cases of the disease one sometimes finds recovery with no evidence of antitoxin in the blood.

*Pathology.*—In addition to the membranous lesions caused by the bacilli themselves, other often more serious disturbances are produced by the soluble toxin. The organs particularly affected are the heart, nervous system and kidneys. Secondary infection with other organisms, especially streptococci and pneumococci, often occurs; it may be responsible for extension of the local infection, may cause

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<sup>1</sup> The Schick test is carried out as follows: With a fine hypodermic needle one-fiftieth of a minimum lethal dose of diphtheria toxin, dissolved in 0.2 c.c. normal salt solution is injected intracutaneously, great care being taken to prevent any subcutaneous injection. A positive result is denoted by the appearance in twenty-four to forty-eight hours of a circumscribed area of redness at least 5 millimeters in diameter. This persists for six to ten days, then gradually fades, leaving a brownish spot that may be appreciable for months. A so-called "pseudoreaction" may appear early, but has usually disappeared by the end of forty-eight hours. A negative result denotes sufficient concentration of antitoxin to neutralize the amount of toxin injected, and means that the individual is immune to the disease. A positive result denotes only that there is insufficient antitoxin to neutralize the amount of toxin injected, but practically means that the individual may be susceptible to the disease. The significance of a "pseudoreaction" is unknown.



pneumonia, or general sepsis. The diphtheria bacilli tend to remain localized on the surface of the affected mucous membranes, and in the false membrane itself; they do not invade deeply the subjacent structures.

The symptoms of diphtheria then depend on (1) the amount and position of the membrane, (2) the amount of toxin absorbed and (3) the presence of secondary invading organisms, especially the streptococcus.

*Diphtheritic Membrane.*—This is most frequently seen upon the mucous membrane of the tonsils, soft palate, uvula, pharynx, nose, larynx, trachea, and bronchi; less frequently upon the mouth, lips, esophagus, conjunctiva, middle ear, stomach, and genital organs. It often stops abruptly at the lower border of the larynx, but in some cases it extends into the trachea and down into the bronchi, reaching the finest subdivisions. The membrane is often not as firmly attached in the larynx and lower air passages as in the pharynx, and sometimes a cast reproducing almost the entire bronchial tree may be expelled. Rarely diphtheria affects the trachea and bronchi without involving the larynx. It may also affect fresh wounds, notably a tracheotomy wound, or any abraded cutaneous surface. In appearance the membrane is dull and opaque, gray or yellowish-white, occasionally a dark blackish-gray in color. It is granular and friable, and varies in thickness, at times becoming bulky enough to obstruct the larynx or bronchi.

The first lesion consists in destruction of a thin layer of the superficial epithelium, often in a number of small patches. An exudate is poured out from the damaged areas and coagulates on the surface. Included in the clot are leukocytes and the dead epithelial cells which have undergone coagulation necrosis. A thin layer of pseudomembrane may be seen in section, connecting the damaged surfaces and overlying the intervening intact epithelium. As the lesion extends, the deeper layers of epithelium become necrotic, and with the products of inflammation add to the membrane, or the original layers become detached and a new one forms. The surviving epithelium is infiltrated sparsely with leukocytes. The vessels in the submucosa are distended and surrounded by cells which have emigrated into the tissues. When necrosis extends into the submucous layers, as it often does, the original minute punctate hemorrhages give place to a much more extensive hemorrhagic zone forming a border between the membrane and the relatively intact tissue beneath; distended small vessels become necrotic and permit the blood to escape. The underlying layers may become inflamed and edematous, infiltrated with leukocytes and some mononuclear cells.

*Effects of the Toxin.*—Acute degenerative changes are produced in the cells of the body by the soluble toxins of the diphtheria bacillus. These changes are of especial importance in the heart, the liver, the kidneys, the hematopoietic tissue, and the nervous system. All the characteristic lesions except the membrane and all the essential symptoms of diphtheria have been produced in susceptible animals by injection of the toxin.

**CIRCULATORY SYSTEM—MYOCARDITIS.**—At autopsy there is found degeneration of the muscle fibers with loss of transverse striations, amounting at times to complete disintegration of the fibers. During life myocarditis is manifested by an alteration in the first cardiac sound, the muscular quality diminishing and the valvular quality increasing so that in severe cases the first and second sounds are



almost alike. Diastole may be shortened and the rhythm become like that in fetal life. Dilatation of the heart occurs and may sometimes be extreme. The pulse is feeble and the blood pressure tends to be low. The conduction system is often affected; prolongation of the P-R interval is common, and there may be higher degrees of block or even complete heart block. A change from a rapid to a slow pulse should be regarded with apprehension.

While myocarditis occurs most often in the severe form of the disease, it may be found in cases that do not seem severe. In many instances the presence of myocarditis can be determined only by the most careful examination, and often it may remain unsuspected until the sudden development of myocardial failure makes it evident. Not infrequently the signs of myocardial failure first appear during convalescence, and sudden death may occur even several weeks after apparent recovery.

Occasionally cardiac thrombosis may cause sudden death during the height of the disease. If the thrombus forms slowly embolism may result, though such an accident is rare. Cerebral thrombosis has occasionally been reported.

LIVER.—The cells in the liver take part in the degenerative changes and at autopsy there are found areas of necrotic cells scattered throughout the liver. Clear evidence of damage to the liver during life is generally lacking. Jaundice does not occur. At the same time, it is probable that hypoglycemia, the occurrence of which in severe cases has recently been emphasized, may have its source in a functional liver damage.

KIDNEYS.—In many of the fatal cases the kidneys show, in addition to cloudy swelling with swollen granular epithelial cells, an interstitial nephritis, with more or less extensive accumulations of mononuclear cells between the tubules. The zone most affected is that at the border between the cortex and the pyramids. Streaks of infiltrating cells extend out toward the surface and may form rings about the glomeruli. A necrotic portion of a tubule is occasionally found in the center of the larger cell masses. The lesion produces no functional impairment and cannot be distinguished from mere cloudy swelling by the urinary findings. An acute glomerular or hemorrhagic nephritis from uncomplicated diphtheria is almost unknown.

BLOOD PICTURE.—Ordinarily the blood shows a polymorphonuclear leukocytosis proportional to the severity of the intoxication; but in severe cases there may occasionally be a neutropenia. Myelocytes have been found increased in some severe cases, but their presence does not necessarily indicate a fatal outcome. A lymphocytic reaction has been reported following diphtheria, but does not occur during the acute stage.

The red cells and hemoglobin are usually reduced, sometimes strikingly so in the severe cases. There is little evidence of regeneration in the acute stage, and the anemia may persist for a long time. The platelets are not ordinarily affected, but in severe cases they may be strikingly reduced.

NERVOUS SYSTEM.—The lesions in the nervous system consist in degenerative changes, which are found to some degree in nearly all severe cases. In the cord changes are found in the ganglion cells of the anterior horns, the anterior and posterior nerve roots, and sometimes the pyramidal tracts and columns of Goll.



Degenerative changes have also been found in the oculomotor, vagus, spinal accessory and hypoglossal nerves, and in their centers in the midbrain and medulla. They do not occur in the cortex.

Some form of paralysis occurs in from 10 to 20 per cent of all cases of diphtheria. Although the probability of its occurrence and its extent is more or less proportional to the severity of the attack, it may occur after a mild attack, especially one that was unrecognized and therefore not treated with antitoxin. The length of time between the onset and the administration of antitoxin is also important. In Rolleston's series, only 3.6 per cent of the cases receiving antitoxin on the first day subsequently developed paralysis, whereas when antitoxin was not given until the third day 21.4 per cent developed paralysis, and when it was delayed until the sixth day 27.1 per cent developed it.

The muscles of the soft palate are generally the first and may be the only ones to be affected. Usually, however, other muscles are involved, especially those of accommodation, less frequently the extra-ocular muscles, the pharynx, the diaphragm and the muscles of the upper and lower extremities. Paralysis of the intercostals is sometimes observed. Walshe divides the paralyses into three groups: (1) the local, or regional; (2) the specific; and (3) the general. He found in diphtheria of wounds, that the earliest paralysis was that close to the part of the body involved in the diphtheritic process, and that general paralysis occurred only in severe cases, while paralysis of accommodation might occur without relation to the occurrence of a general paralysis. He therefore called the paralysis of accommodation "specific" and drew analogies with the well-known effect of tetanus toxin. If this is true it is easy to understand why the palate should be the first to be affected in the usual form of diphtheria, and why the paralysis of accommodation should occur so much more frequently than other paralyses with the exception of that of the palate.

In general, the more severe the attack of diphtheria, and the longer the patient has been without antitoxin the earlier will the paralysis appear and the more widespread will it eventually be. In severe cases on the fifth or sixth day there may be present signs of palatal paralysis consisting in nasal voice and regurgitation of fluids through the nose. This, however, does not usually occur until the second week. The later it occurs, the less likely is paralysis to be widespread, and if there is no evidence of paralysis by the end of the third week it is probable that the child will escape altogether.

Ocular paralyses do not usually occur before the third week. The most common form is paralysis of the muscles of accommodation. This is best detected by the child's inability to read and is therefore not likely to be recognized in very young children. Less commonly there is strabismus, usually internal, affecting one or both eyes.

General paralysis rarely develops before the fifth week or after the eighth and is almost always preceded by that of the palate or accommodation. In addition to the forms already mentioned, there may occur paralysis of the pharyngeal muscles so that swallowing is difficult or impossible, and in severe cases the extremities, the neck, and the diaphragm may be affected. Involvement of the muscles of the neck renders it difficult or impossible to raise the head and is responsible



for a characteristic picture in diphtheritic paralysis. The knee jerks are nearly always lost, even when the process is very limited in extent, but the superficial reflexes are retained unless the paralysis is widespread.

Respiratory paralysis is seen in severe cases and is usually due to involvement of the phrenic nerves. The first warning is generally in the form of occasional attacks of dyspnea, sometimes accompanied by cough. Gradually these attacks increase in frequency and severity. The voice is reduced to a whisper. As the diaphragm is usually affected, the breathing is entirely thoracic. The respiratory movements are rapid, but irregular, shallow, and ineffectual. There is cyanosis, also great subjective as well as objective dyspnea. The anxiety, distress, and apprehension of the patient are sometimes terrible. There is a constant dread of impending suffocation, and the respiratory movements are continued only by the patient's constant effort, otherwise they would cease altogether. After a few hours these severe symptoms may subside, to return after a short respite. There may be several such attacks during two or three days, in each of which death seems imminent.

The period during which any form of paralysis is at its height is not usually prolonged beyond a week or ten days, even in the severest cases, so if the patient with respiratory paralysis can be tided over this period recovery will be spontaneous. Death may be due to the extent of the respiratory paralysis, to pneumonia or to myocarditis, which is so frequently associated, especially in the severe cases.

OTHER LESIONS DUE TO THE TOXIN.—Degenerative changes occur in the lymph nodes, especially of the cervical region, less commonly of the tracheobronchial and mesenteric groups. The nodes rarely suppurate. The spleen is swollen and deeply congested and cellular degeneration similar to that in the lymph nodes occurs. Punctate hemorrhages may be seen at autopsy under the capsule of the liver and spleen. Subcutaneous hemorrhages usually in the form of petechial spots occur in the cases with severe toxemia. The cause of these hemorrhages is not uniform. In some cases they are associated with reduction in platelets, in others they may be the result of degenerative changes in the vessel walls.

*Association with the Streptococcus or Other Organisms.*—Streptococci are present in most cases of more than moderate severity, and while their tendency to invade surrounding tissues and produce suppurative lesions is far less than in

TABLE XLIX  
ORGANISMS FOUND IN DIPHTHERIA AT AUTOPSY

	Heart's Blood, Per Cent	Liver, Per Cent	Spleen, Per Cent	Kidneys, Per Cent
Diphtheria bacillus .....	6	20	12	19
Streptococcus .....	20	30	27	28
Staphylococcus aureus .....	2.5	4	3	8
Pneumococcus .....	1.5	2.5	1.5	5

scarlet fever, they not infrequently invade the blood stream, causing a septicemia. Other organisms are much less frequently found in the blood and organs at autopsy, as is shown in Table XLIX from a series studied by Councilman, Mallory and Pearce.



In this series, 153 were cases of pure diphtheria; 56 were complicated by measles or scarlet fever or both. Streptococci were much oftener found in the viscera in the complicated cases; otherwise there was little difference in the two groups.

The most frequent severe complication for which streptococci or pneumococci are responsible is a bronchopneumonia, which occurs especially in young children with laryngeal involvement. In fact, at the present time death in the course of laryngeal diphtheria is more commonly due to pneumonia than to stenosis of the larynx. Although pneumonia is much more likely to occur following laryngeal involvement, it is frequently present in the very severe pharyngeal cases as a terminal event.

Death in diphtheria is due (1) to the severity of the toxemia, the immediate cause of death being myocardial failure; (2) to laryngeal stenosis; (3) to bronchopneumonia, often as a result of direct extension downward to involve the lower air passages; (4) to late myocardial failure; (5) to respiratory paralysis. This last is relatively rare.

**Symptoms.**—The incubation period of diphtheria is short, usually between two and five days. During this time there is nothing by which a diagnosis can be made. In a mild case or one of moderate severity, the onset is accompanied by a little soreness of the throat and an initial temperature of from 101° to 104° F., but the symptoms are often not severe enough to keep the patient in bed. If seen early, the throat shows slight redness, followed by a gray or white deposit upon the tonsils. This may start as a single patch which enlarges, or as small, isolated spots which coalesce or remain separate. The membrane is quite adherent, cannot easily be removed with a swab, and usually is sharply defined. The inflammatory changes in the pharynx are slight. The lymph glands behind the jaw may be slightly swollen. The temperature commonly continues above normal while the membrane lasts, its usual range being from 100° to 103° F. The membrane remains from three to seven days—a shorter time if antitoxin is used.

While in the mild cases the membrane is limited in extent or in some cases absent altogether and the constitutional symptoms slight, in the more severe cases the membrane tends to spread over the fauces and uvula, then to the pharyngeal wall and from there upward to the posterior nares and even into the accessory sinuses, or downward to involve the larynx. With a large surface involved the absorption of the toxin is proportionately greater and the constitutional effects more severe. The onset is often as insidious as in the milder forms, and the temperature but little elevated, but the symptoms progress steadily in severity, reaching their maximum in four or five days. At other times, especially in younger children, the disease begins abruptly with vomiting, headache, chilly sensations and a temperature of 103° to 104° F.

When a severe case is fully developed there is an abundant discharge of mucus from the mouth and nose. The tonsils, the entire faucial ring, and the pharynx are covered with membrane, which is at first gray and gradually becomes darker, often being of a dirty olive-green color. There is obstruction to nasal respiration from the swelling of the palate, the tonsils, and the adenoid tissue of the rhinopharynx; the mouth is half open, the breathing noisy, the tongue dry,



the lips fissured and often bleeding. Occasionally large nasal hemorrhages occur which may necessitate plugging the nares. Both nostrils are generally blocked by the swelling and the false membrane; the nasal discharge excoriates the upper lip, and frequently has a fetid odor. During the second week there may be regurgitation of fluids through the nose, owing to paralysis of the palate. The lymph glands at the angle of the jaw swell rapidly, and there may also be extensive infiltration of the cellular tissue about them.

The constitutional symptoms usually increase steadily with the extension of the membrane. In the most severe cases the system is overwhelmed with the poison, and all the evidences of intense toxemia are present by the third day of the disease. This is shown by great prostration, by a feeble, rapid and sometimes irregular pulse; the heart sounds are faint and there is a great and steadily increasing anemia. The course of the temperature is irregular, and may bear no constant relation to the severity of other symptoms. Its usual range is from 101° to 103° F., but in some of the worst cases it may not go above 101° F. It fluctuates irregularly with the development of complications, and sometimes without apparent cause. By the second or third day the urine regularly shows the presence of albumin, and by the end of the first week the quantity is often large. Granular and hyaline casts, and occasionally blood in small quantities, are also found. Nervous symptoms are seen in all the very severe cases. There may be dullness and apathy, but more frequently, owing to the discomfort arising from local symptoms, there is extreme restlessness and excitement, sometimes delirium.

The local process in the pharynx seems to be a self-limited one even when no antitoxin is used. It usually reaches its height by the fifth or sixth day, and after that the appearances do not change materially for two or three days. After this time, in favorable cases, the diphtheritic membrane begins to loosen and separate from its attachment. With the disappearance of the membrane the local symptoms abate rapidly—the discharge ceases, the swelling of the lymph glands subsides, deglutition becomes easy and natural, and nasal breathing is reestablished. When antitoxin is given the local process passes through similar stages, but much more rapidly.

Simultaneously the constitutional symptoms improve, but much more slowly. Convalescence is often protracted. The anemia and muscular weakness, and most of all the feeble heart action, may persist for weeks. Symptoms due to myocarditis may appear in the second or third week or even later.

Instead of the usual course just described, the diphtheritic membrane may persist for two or three weeks. In rare cases relapses occur, the membrane forming again after it has entirely or partially disappeared.

*Laryngeal Diphtheria.*—The larynx may be involved by the spread of the pharyngeal membrane in severe cases, or may be affected primarily. In the latter case the severe constitutional symptoms characteristic of the pharyngeal form are usually lacking. This is probably due partly to the rapidity with which the disease in its severe form progresses to a fatal termination from local causes, and partly to the fact that the absorption of toxin from the larynx is feeble as compared with that which takes place from the pharynx.

In its onset, diphtheria of the larynx is indistinguishable from simple catarrhal



inflammation. It is usually less abrupt, and at first apparently not so severe. There are present the same hoarse cough and voice, with slight stridor, gradually increasing. The constitutional symptoms are usually not quite so marked, the temperature ranging from 99° to 101° F. It is the progress of the disease which indicates its character. A child beginning in the morning with such symptoms as have been described, may by evening show a decided change for the worse, or the symptoms may increase with great rapidity during the night. At first the voice is hoarse; later entirely lost. Very occasionally the membrane and inflammation are situated entirely below the vocal cords. The voice may then be retained. Dyspnea in the beginning is scarcely noticeable, but steadily increases hour by hour. During the second twenty-four hours all the symptoms are usually well developed. The respiration is at times somewhat accelerated, but it is usually slower than normal. The face is pale and anxious. The alae nasi dilate with each inspiration. Loud, "sawing," stridulous breathing is present, indicating obstruction both to inspiration and expiration. As the dyspnea increases, all the accessory muscles of respiration are brought into action. There is now with every inspiration deep recession of the suprasternal fossa, the supraclavicular regions, and the epigastrium. Inspiration and expiration are both labored. The child tosses uneasily from side to side in his crib, at times struggling violently to get more air into and out of the lungs. The pulse grows rapid and weaker. There is slight blueness of the fingernails and the lips; the face is usually pale, but later this too may be cyanotic. The skin is covered with clammy perspiration. On auscultating the chest, rough respiratory sounds are heard, but no vesicular murmur. As the symptoms increase in severity the temperature usually rises progressively, in some severe cases at the rate of a degree an hour, until shortly before death it reaches 104° or 106° F. Late in the disease the intellect becomes dull, the violent struggles for air cease, cyanosis gives way to pallor, and the child passes into a condition of semistupor which gradually deepens until death occurs. This may be preceded by convulsions.

Such is the course of the disease when unrelieved by treatment. Its progress is most rapid in infants, in whom death often takes place in from thirty-six to forty-eight hours from the first symptoms. In older children the course is rather slower, and the attack may last from two to five days, death occurring more frequently from pulmonary complications; these are indicated by continued high temperature, rapid respiration, cyanosis, and increased prostration. Great improvement may follow the dislodgment of the membrane by vomiting or coughing, although in most cases it forms again.

*Nasal Diphtheria.*—The nose may be involved by extension of the pharyngeal process upwards and in severe cases the accessory sinuses may also be affected. Primary nasal diphtheria is most frequent in infants or very young children. The constitutional symptoms are mild or lacking, and the only constant sign of the disease is a persistent nasal discharge which is often tinged with blood and causes excoriation about the nostrils.

*Malignant Diphtheria.*—The ordinary severe form of diphtheria has been described, but there is a form which goes under the name "malignant diphtheria," which is extraordinarily fatal and is so intimately associated with the streptococcus that it is difficult to determine whether the symptoms are due to the diphtheria



bacillus or to the streptococcus. The symptoms are usually severe from the outset. The membrane is usually extensive, covering the entire pharynx, often extending to the nose and the middle ear, and occasionally spreading to the buccal cavity. There is great swelling of the tonsils and uvula, and it is often impossible to obtain a view of the pharynx. Sometimes the inflammation is of a necrotic character, and there may be extensive sloughing of the tonsils, the uvula, or the soft palate. The nasal discharge is generally abundant, and often offensive. There is marked swelling of the cervical lymph glands, and frequently extensive infiltration of the cellular tissue of the neck, so that the head is thrown back to relieve the pressure upon the larynx and trachea. The swelling sometimes forms a distinct collar, reaching from ear to ear and filling out the whole space beneath the jaw (bull-neck). The pressure upon the jugular veins leads to congestion and swelling of the face and congestion of the brain. The temperature is usually high; it follows no regular course, but generally fluctuates widely from  $102^{\circ}$  to  $106^{\circ}$  F. In some cases, however, it may never be above  $101^{\circ}$  F. The pulse is weak, rapid, and compressible. The peripheral circulation is poor, the extremities are often cold, there is extreme muscular prostration, and both vomiting and diarrhea are frequent. There may be excitement, restlessness, and active delirium, or dullness, apathy, and stupor. Nephritis is very frequent and is often severe; the urine contains a large amount of albumin and casts of all varieties, but rarely blood. Streptococci or pneumococci, usually the former, can frequently be cultivated from the blood. Death generally occurs while the local disease is at its height, and may result from the invasion of the larynx or from nephritis, but more frequently from pneumonia and circulatory failure. Evidences of myocarditis are present post mortem in nearly every case of this type. Those who manage to escape the dangers of the acute period may succumb later with extensive sloughing in the throat or of the cellular tissue of the neck, followed by severe hemorrhage or diffuse suppuration of the same region; or death may be due to late nephritis, pneumonia or myocarditis.

**Diagnosis.**—Although a positive diagnosis of diphtheria must rest on the demonstration of virulent diphtheria bacilli, it is not always safe to wait for the results of bacteriological examination before antitoxin is given. In the severe cases, where toxic symptoms are already present, there will rarely be difficulty in diagnosis sufficient to justify withholding antitoxin, while in the mild cases without characteristic membrane or in those with primary nasal diphtheria no harm will come from waiting for the bacteriological diagnosis. It is in the early stages before the membrane is widespread or when signs of croup are beginning that the chief diagnostic difficulties will be encountered.

There is nothing specific about the onset of diphtheria. Neither the color of the membrane nor the fact that it appears first upon the tonsils is characteristic, but extension from the tonsils to other parts of the pharynx is most typical. The rapidity of spread varies greatly in different cases, but progressive extension, as shown by observations made at intervals of six or eight hours, usually settles the diagnosis in the primary cases. If the throat symptoms complicate measles or scarlet fever the above rules do not apply. Most of the membranous inflammations of the throat seen in these diseases, especially when they occur at the height of the



disease, are not due to diphtheria. Those which develop at a later period are often due to diphtheria.

Primary membranous inflammation of the larynx may always be tentatively regarded as diphtheria. If there is no visible membrane in the pharynx, the larynx should be inspected by means of the laryngoscope. Membrane may often be seen in the larynx when there is none in the throat. In case no membrane can be seen in the larynx the diagnosis is rendered positive only by cultures, which can be made directly from the larynx through the laryngoscope.

It may be difficult in a given case to decide whether the dyspnea is due to laryngeal inflammation, and whether this inflammation is catarrhal or diphtheritic. The dyspnea of retropharyngeal abscess, of foreign bodies in the larynx or trachea, or of pneumonia, may be mistaken for that due to laryngitis. But in none of these conditions should there be any doubt if a careful examination is made and a history obtained. Retropharyngeal abscess may be recognized by digital examination of the pharynx, the voice is not lost; pneumonia by the signs in the lungs, and by the absence of noisy stridor. In brief, diphtheritic inflammation may be assumed if there is severe, constant, and increasing dyspnea with aphonia.

*Bacteriological Diagnosis.*—In many cases an immediate diagnosis may be reached by the examination of a cover-glass smear from the throat. This method is not adapted for general use, as bacilli obtained directly from the throat are much less typical than those from cultures, and the chances of contamination are much increased. Furthermore, the mouth often contains other organisms which somewhat resemble the diphtheria bacillus.

In taking a culture from the throat nothing but the membrane should be touched and this should be rubbed firmly with a swab, which is then rubbed over the surface of the culture-medium. In laryngeal cases the culture should be taken from the posterior wall of the pharynx, or preferably directly from the larynx through a laryngoscope, and in nasal cases from the nostril.

Cultures taken from a diphtheritic membrane during the acute stage will almost invariably be found to be positive. Negative results, however, may be obtained in laryngeal diphtheria where there is no pharyngeal membrane, and in late cases in which the membrane is beginning to loosen, or after it has disappeared. Diphtheria bacilli often persist in the crypts of the tonsils for long periods after the attack is over, and may then be relatively inaccessible. A single negative culture should not be taken as conclusive evidence that diphtheria bacilli are not present.

Difficulty also arises from the existence of organisms that are morphologically similar to the diphtheria bacillus, as well as from the existence of nonvirulent diphtheria bacilli. In cases clinically suspected, any organisms having the cultural and morphological characteristics of diphtheria bacilli are to be regarded as virulent, even though later doubt as to the correctness of the diagnosis may make it advisable to carry out virulence tests on animals. There are instances in practice where a faulty diagnosis of diphtheria will work undue hardship through quarantine of homes or places of business or the isolation of individuals, in which case virulence tests should be insisted on. Such situations arise especially during attempts to stamp out epidemics through a search for healthy carriers or at times when



routine bacteriological examination of throats is being carried out. Moss and Guthrie took cultures from 1217 public school children in Baltimore. In 44 children diphtheria bacilli were found, but in only 8 were they virulent.

**Prognosis.**—The factors to be considered in the prognosis of any given case are: the age and previous condition of the patient; the extent of the membrane and the rapidity with which it is spreading; the degree of diphtheritic toxemia as shown by the condition of the pulse and the nervous symptoms; whether or not the membrane has invaded the larynx; and the presence or absence of complications, especially pneumonia; but of more importance than any or all these things is whether antitoxin is used and when it is administered.

The following figures are from a report of the Health Department of Chicago of cases treated for a series of years.

TABLE L  
INFLUENCE OF TIME OF INJECTION OF ANTITOXIN ON MORTALITY

Time of Injection after Onset	Patients	Died	Mortality, Per Cent
1st day .....	355	1	0.27
2d day .....	1,018	17	1.67
3d day .....	1,509	57	3.77
4th day .....	720	82	11.39
Later .....	469	119	25.37
TOTAL .....	4,071	276	6.77

Diphtheria mortality is highest during the first two years of life, from its strong tendency to invade the larynx and lower air passages, and from the frequency with which pneumonia occurs as a complication. Those whose experience with this disease does not antedate the introduction of antitoxin can scarcely appreciate the results previously obtained. In diphtheria hospitals, where most of the mild cases would probably not have been admitted, the mortality in children under two years formerly varied from 60 to 80 per cent.

**Prophylaxis.**—*Isolation of Suspected Cases and Contacts.*—Every case in which diphtheria is suspected should be immediately isolated pending the result of the bacteriological examination. If diphtheria exists in a house the other children from that house should not be allowed to attend school or mingle with other children, because they may themselves carry the organisms. If they are removed from contact with the case, they may be allowed contact with other children only after bacteriological examination has shown them to be free from virulent bacilli. If diphtheria bacilli are found in the throats of contacts, they should be isolated as rigorously as if they had the disease. During an epidemic of diphtheria, especially in an institution, every child with sore throat or nasal discharge should be looked upon with suspicion and isolated, pending the result of a bacteriological examination, even though no membrane is present. If there are patches on the tonsils or any other visible membrane, the case should be treated as true diphtheria, in order that no time may be lost. If the bacteriological examination shows the disease not to be true diphtheria, the patient may be released from quarantine in



two or three days, provided the throat symptoms disappear. Should symptoms continue, a second culture should be taken. It is, of course, important that the conditions laid down with reference to bacteriological diagnosis shall have been fulfilled.

Quarantine should be continued until virulent bacilli have disappeared from the throat. The persistence of bacilli was investigated by the New York Health Department in 605 cases: in 304 of these the bacilli had disappeared by the third day after the membrane was gone; and in 301 cases they persisted for a longer time. While it is unquestionably true that in a certain number of cases these persistent bacilli are nonvirulent, the opposite has been frequently shown. Of 15 cases in which the virulence was tested, virulent bacilli were found in 9 at periods varying from eight to twenty-five days after the membrane was gone.

TABLE LI

PERSISTENCE OF DIPHTHERIA BACILLI AFTER DISAPPEARANCE OF MEMBRANE

	Cases	Per Cent
Less than 3 days .....	304	50.3
7 days .....	176	29.0
12 days .....	64	10.6
15 days .....	36	5.9
3 weeks .....	12	2.0
4 weeks .....	4	0.7
5 weeks .....	4	0.7
9 weeks .....	2	0.3
More than 9 weeks.....	3	0.5
TOTAL .....	605	100.0

*Immunization of Persons Exposed.*—When a case of diphtheria occurs in a family or institution, every child and all adults should have their immunity determined by the Schick test, and those with a positive test should be given 500 to 1000 units of antitoxin. The procedure will confer immunity for two to three weeks. When it is impossible to apply the Schick test, children under five years of age should be immunized with antitoxin at once. With older children immunization may be postponed, provided only that they can be observed at least twice a day. If this cannot be done, all children under ten years of age should receive a prophylactic injection of antitoxin. Those older may be treated as adults are treated, by close observation but without antitoxin unless sore throat or other suspicious symptoms arise.

A nurse who is not immune to diphtheria should not work in infectious hospitals nor, ordinarily, care for diphtheria patients in private practice. If it is necessary for her to take care of a diphtheria patient she should receive 1000 units of antitoxin. These general rules do not apply to physicians, who are in less close contact with patients. They should take the same precautions as in scarlet fever.

*Production of Permanent Immunity.*—By the injection of toxin-antitoxin mixtures, it is possible to confer a lasting immunity on from 70 to 90 per cent of all children so treated. It is usually given in three injections at weekly intervals. Antitoxin made from sheep or goat serum may be used instead of that prepared



from horse serum where it is desired to avoid any possible allergic reaction. Antitoxin (toxin treated with formaldehyde, also known as toxoid) has lately tended to supplant the toxin-antitoxin mixtures; it contains no animal serum and eliminates one source of untoward reactions. The alum-precipitated toxoid has the advantage that only one dose is required. The results obtained with toxoid are practically the same as with toxin-antitoxin. Löwenstein has recently advocated percutaneous immunization by means of an ointment applied to the skin. The procedure is usually effective, but the results appear to be less constant than when immunization is carried out by subcutaneous injection. Artificially produced immunity does not appear at once but may require six months or more to develop. The Schick test indicates whether the desired immunization has been achieved. Instances of clinical diphtheria in individuals who have demonstrable circulating antitoxin are almost unknown. Whether or not it is desirable to compel immunization of children to diphtheria as is done in the case of smallpox is largely a political question, but until this is done, the responsibility rests on physicians to persuade parents to have their children immunized.

**Treatment.**—*General.*—Rest in bed should be insisted upon even in mild attacks, while in severe attacks this should be continued some time after convalescence.

Food should be such as is given in any severe illness. Infants should not be allowed to nurse from the breast. Gavage may be used if there is strong aversion to food so that vomiting becomes frequent, when swallowing is difficult because of pain or paralysis, or in infants with great nasal obstruction.

Internal medication should be omitted except for the control of symptoms. If sedatives are used they should be given in sufficient doses to obtain their full effect. They are particularly indicated during convalescence when there is danger from myocarditis. Cardiac stimulants are to be avoided.

Attention has recently been drawn to a tendency to hypoglycemia occurring in severe cases, probably as a result of liver damage. Schwentker and Noël have reported favorable results in such cases from the intravenous injection of glucose.

*Local treatment* should be directed toward keeping the air passages free of material that might be aspirated into the lungs. For this purpose irrigation should be used, especially when there is profuse nasal secretion. Irrigation, however, should not be too strongly insisted upon if the patient shows much resistance, because of the danger of cardiac failure. Gargles may be used by older children. Nasal hemorrhage requires discontinuance of irrigations.

External applications have no effect upon the disease, but ice-bags may be used to relieve pain in the swollen lymph glands.

*Antitoxin.*—In all cases in which the clinical diagnosis is reasonably certain, antitoxin should be used without delay; it neutralizes toxin that is absorbed after its administration, but cannot rectify the damage already done. In the case of a child with the picture of follicular tonsillitis, one can safely wait for the bacteriological diagnosis, keeping the child under observation. If in the course of twelve hours, however, the membrane has shown a tendency to spread and especially if it has begun to involve the uvula or palate, antitoxin should be given without further delay. The younger the child the greater the danger of delay. In cases of



laryngitis without pharyngeal involvement, if there is any doubt, and a direct laryngoscopic examination is not possible, antitoxin should not be withheld.

The injection is preferably made into the muscles of the buttocks, except in severe cases or those receiving antitoxin late, when it should be given intravenously. It is better to give the maximum required dose in a single injection. The number of units required depends on the age of the patient and the severity of the disease. Children under two years of age should receive 5000 or 6000 units; over two years of age, 7000 or 8000 units. In severe cases 10,000 to 15,000 units should be given; in mild cases, 3000 to 5000 units will be sufficient. Only antitoxin of proved potency should be used, and for injection into the blood stream it is preferable to use that prepared especially for intravenous injection. Within a few hours after the injection there is often a sharp rise in temperature, accompanied by a chill. There is no cause for alarm when this happens.

In a few instances sudden death has followed antitoxin injection, but the evidence that serum was the cause of death has not always been conclusive. Fatal protein reactions are exceedingly rare, although mild ones are not so very uncommon. It is a wise precaution to test for sensitiveness to the serum before injecting antitoxin, especially in a child with a history of asthma or hay fever, or of hypersensitiveness to protein in any form, or in one who has previously received injections of horse serum. The procedure to be used in such cases is described elsewhere (p. 730).

There is no doubt at the present time of the efficacy of treatment with antitoxin. The general mortality from the disease has been reduced to a little more than one-third of the pre-antitoxin figures. When antitoxin has been given late, *i.e.*, after the third day, and in malignant cases, little effect may be hoped for. For the late manifestations of diphtheria, myocarditis or paralysis, antitoxin is of no value.

*Convalescence.*—After a severe attack of diphtheria convalescence is always slow on account of the anemia and the depressing effects of the disease. Patients should invariably be kept in bed for at least a week after the throat has cleared, and much longer if any tendency to cardiac weakness is seen. The pulse should be carefully watched, and irregularity, dicrotism, or a weak first sound of the heart should make one apprehensive. An abnormally slow pulse is generally more serious than one which is rapid. In such circumstances the patient should be kept recumbent and absolutely quiet, since fatal syncope may be the result of a violation of these rules. The extreme degree of anemia frequently requires that iron be given for a considerable time during convalescence.

Great difficulty is occasionally experienced in getting rid of the bacilli in the throat. The tonsillar crypts, the adenoid tissue of the rhinopharynx, and the nasal sinuses are the places where they are most likely to remain. Inasmuch as it is now generally made a condition of release from quarantine that the throat shall have been shown by cultures to be free from bacilli, this becomes a matter of much importance. We have had no success with local applications, syringing or gargles. When bacilli are very persistent, as they often are for weeks, their virulence should be tested. In many such cases they are found to be nonvirulent and further quarantine is unnecessary. When virulent bacilli persist for a long time,



the question of the removal of the tonsils should be considered. It is often successful when all other means of getting rid of the bacilli have failed.

*Treatment of Diphtheritic Paralysis.*—If virulent diphtheria bacilli are present, the case should be treated as an active one, with isolation and antitoxin. If the throat is clear of virulent bacilli these two measures may be omitted. It must be remembered, however, that in all cases in which the nervous system is involved, it should be assumed that the myocardium has also been affected, even though signs of myocarditis are lacking. The patient should be kept at rest as completely as possible and should be watched most carefully for myocarditis. The paralyses themselves need no treatment. Gavage will be necessary if there is pharyngeal paralysis sufficient to interfere with swallowing. In the case of respiratory paralysis, means must be used to keep the patient alive until spontaneous recovery takes place, usually after about a week or ten days. Oxygen may be of assistance when the paralysis is not complete. With complete or almost complete paralysis artificial respiration must be applied continuously. A respirator such as that devised by Drinker has been used successfully, but unfortunately such instruments are rarely available.

*Treatment of Laryngeal Diphtheria.*—There are three factors to be taken into account in laryngeal stenosis: (1) the membrane; (2) the swelling of the mucous membrane due to hyperemia or edema; (3) the possibility of spasm of the larynx. While the membrane plays the most important part, the other two factors are often responsible for causing the rapid development of extreme stenosis. Therefore, everything must be done to quiet the apprehension of the patient so that he will cease to struggle and breathe more quietly. Morphine should be used in full doses, and in some cases it may be well to withhold antitoxin until the patient is under the influence of morphine so as to avoid as far as possible the disturbance that is bound to follow the injection of serum. It often is surprising how much the signs of stenosis may be relieved as soon as the patient is asleep.

Opinions will always differ as to the time when operative procedures are called for. Intubation or tracheotomy should be delayed until it is evident that it cannot be dispensed with, especially in children under two years of age, for it is in these that one encounters the greatest difficulty in permanent removal of the tube later on. On the other hand, it is unwise to wait for general cyanosis, for then death is imminent and relief may come too late. In cases with much pharyngeal membrane, and consequent greater absorption of toxin, the struggle for breath may overtax an already damaged heart. In these cases intubation will have to be performed earlier than in the pure laryngeal cases. Much relief may be obtained by suction through a direct laryngoscope to remove membrane and secretions from the larynx. This may have to be repeated as the membrane forms again. It cannot be too much emphasized, however, that the most important procedure is to let the patient sleep, and any procedure that may add to the patient's apprehension should be delayed until it is evident that it will be unavoidable, and then one should be prepared to intubate at any instant. Although the use of a steam tent cannot be relied on, it may occasionally tide a patient over until recovery begins.



INTUBATION.—Intubation is the introduction of a tube through the mouth into the larynx for the relief of laryngeal dyspnea. For the operation, as now performed, the world is indebted to O'Dwyer, of New York.

Experience has clearly proved that intubation relieves the dyspnea due to laryngeal stenosis promptly, efficiently, and certainly; it does this without many of the dangers and objectionable features of tracheotomy, while at the same time it does not deprive the patient of any essential advantage which tracheotomy affords.

A set of O'Dwyer's instruments consists of tubes, an introducer, an extractor, a mouth-gag and a gauge. No one thing is more essential to success with intubation than properly constructed instruments. The operation is not difficult if one has had practice on the cadaver. Without this it should not be attempted. The tube is selected according to the age of the patient, this being indicated on the gauge. A very large child will often require a tube of larger size than his age would call for.

INTRODUCTION OF THE TUBE.—Either one of two positions may be employed, the choice depending upon the preference of the operator. In one the child is seated upon the lap of a nurse while his head is steadied by a second assistant standing behind. In the other position the child lies upon his back upon a table, his head being steadied by an assistant. In both positions the arms should be pinioned to the sides by a sheet. The tube is attached to the introducer, and the gag is inserted at the left angle of the mouth and opened as widely as possible.

The epiglottis is drawn forward by the index finger of the left hand, which is also used as a guide for the tube. As soon as the end of the tube reaches the opening into the larynx the introducer is raised so the tube will be pointed slightly forward, and as gently as possible inserted into the larynx. The introduction should be made quickly, for during the attempt respiration is practically arrested. It is important that the tube and introducer be kept in the midline during the procedure and that force should not be used.

When it is certain that the tube is in position, and the patient breathes properly, the loop of silk attached to the head of the tube is cut off and pulled through, the removal of the tube being prevented by placing the left forefinger upon its head. The silk is not usually left attached unless there is evidence of loose membrane below the tube. It may be desirable to leave the silk attached in case no one is within reach who is able to remove the tube should it become obstructed. The child's arms and hands should then be secured to prevent him from seizing it himself. When not removed, the silk is fastened to the cheek by a piece of adhesive plaster. The tube is known to be in place, first, by the hissing breath sounds, somewhat similar to what is heard when the trachea is opened; secondly, by a severe paroxysm of coughing, which is usually excited by a tube in the larynx; thirdly, by the relief of the dyspnea. The most common mistake made is to pass the tube into the esophagus. If this is done there will be no relief from dyspnea and the tube should be immediately withdrawn by the silk loop and another attempt made. Rarely membrane may be pushed down in front of the tube, completely obstructing it. This is one of the most serious accidents that may happen, and necessitates immediate withdrawal of the tube. If the complete obstruction to breathing persists tracheotomy must be performed immediately. Occasionally also a child may fail to breathe after the successful introduction of the tube. In such a case artificial respiration will be necessary. If there is no obstruction to the tube, this will usually be successful.

REMOVAL OF THE TUBE; EXTUBATION.—The general arrangement of the patient and assistants is the same as for introduction. The left index finger is placed upon the head of the tube. The beak of the extractor is introduced within the opening of the tube, its jaws are then separated by pressure upon the lever at the handle, and the instrument withdrawn, very slight force being required.

The tube is first removed tentatively, the physician waiting to see if dyspnea returns. A dose of morphine or codeine should be given an hour before the removal of the tube, since the operation is almost invariably followed by a marked degree of laryngeal spasm



which lasts for several minutes. To avoid the production of vomiting and the entrance of food into the larynx, food should not be given for three hours previously. After extubation absolute quiet and freedom from apprehension is imperative. Fear of a return of dyspnea is one of the most potent factors in its return. If dyspnea does not return in the course of three or four hours, the probabilities are that the tube will no longer be required.

There is always some degree of hoarseness following intubation, but in the majority of cases it disappears within a week; occasionally it continues as long as three or four weeks, but is rarely if ever permanent. The duration of the aphonia seems to have little relation to the length of time the tube is worn, unless this is many weeks.

**TREATMENT OF INTUBATED CASES.**—So far as the tube itself is concerned no treatment is required. The original disease is to be treated as before. The operation has removed only one danger from the patient—that of asphyxia from mechanical obstruction of the larynx.

The child should not be allowed to lie upon his face, nor should he be held over the nurse's shoulder face downward, for in either position a slight cough is enough to expel the tube. Infants may be fed from the bottle; ordinarily they have but little difficulty in swallowing. Older children often experience considerable trouble in taking liquids. When fluids cause excessive coughing, or at other times when they can be taken only with the greatest difficulty, they may be given through a nasal tube or one passed through the mouth. Semisolid articles, such as milk gruels, custards, wine jelly, cornstarch, ice cream, or scrambled eggs, may be well taken when fluids are not. Feeding is always easier after the first day or two, and patients who wear a tube for chronic disease soon experience no trouble whatever.

A tube may be coughed up either because it is too small or because of the subsidence of laryngeal swelling. Should this happen its reintroduction should be delayed until dyspnea returns. Occasionally the tube may be swallowed, and the fact that it is not in the larynx be unsuspected until dyspnea returns.

Sometimes, however, usually after the tube has been worn for a week or more, it may be coughed up because of relaxation of the tissues. As patients in such circumstances are unable to breathe for more than a few minutes without the tube and are unable to retain the tube for more than a short time, it is usually necessary to perform tracheotomy.

Deep ulceration at the head of the tube rarely occurs, provided properly made tubes are employed, but superficial ulceration is almost invariably produced at the base of the epiglottis and in the trachea at the lower end of the tube. Deep ulcers extending to the tracheal rings may occur in ill-conditioned children, usually in connection with other complications serious enough to cause death. Spontaneous descent of the tube into the larynx is not easy, and it cannot be crowded down without using considerable force and severe laceration of the larynx, unless there is a great disproportion between the size of the larynx and that of the tube.

The period for which the tube is required varies much in different cases. It has been materially shortened by the use of antitoxin. The average time of wearing the tube is about five days, and in many it can be dispensed with in two or three days. An attempt should be made to have the child go without the tube



whenever the temperature reaches normal. If complications are present that still cause fever, extubation should not be deferred beyond the fifth or sixth day. The majority of cases do not require re-intubation. If this is necessary, extubation should be done again in three or four days and repeated thereafter at this interval until the tube is no longer necessary. If, after two or three weeks, the tube cannot be dispensed with, it becomes a question whether to continue longer with intubation or to perform tracheotomy.

One would be inclined to temporize and continue intubation indefinitely were it not for the fact that permanent and irretrievable damage may result from the prolonged presence of the tube. If such damage takes place an intubation or tracheotomy tube must be worn throughout the rest of life. One can never foretell how much time must elapse to produce serious damage. In some children it apparently requires only a few weeks. In every diphtheria hospital the experience has been about the same, *i.e.*, that difficulty is encountered in dispensing with the tube in about 5 per cent of the cases of intubation. Every effort proves futile. Although children breathe well with the tube in place, still if it is removed or expelled by coughing, in a short time, varying from a few minutes to several days, the dyspnea returns with such severity that the tube must be replaced to prevent asphyxia. Many of these children, after wearing tubes of one sort or another for years, ultimately die from some accident connected with the tube or from pneumonia.

The causes and exact pathological condition underlying this difficulty are subjects regarding which there has been much difference of opinion. The cause of the returning dyspnea in many instances is probably subglottic swelling and edema which, as soon as the pressure of the tube is removed, occur in the tissues which are the seat of chronic inflammation. In a few cases there is extensive ulceration with destruction of part of the cartilages and metaplasia into bone of parts of others. Deforming cicatrization is then bound to occur. In other cases tracheal granulations with subsequent scarring play an important part. The chronic inflammation of the mucous and submucous tissues of the subglottic region of the larynx which produces the symptoms, is aggravated by a faulty tube or a clumsy operation, but it may occur under the most favorable conditions. Small children are especially likely to have serious changes produced in the larynx.

Some cases, it is true, can be cured by employing larger and larger tubes for months or even years, but there is a considerable proportion who are not improved by it, who must wear the intubation tube constantly or who for one reason or another require tracheotomy. The tendency now is to attempt to prevent severe changes in the larynx by resorting to tracheotomy much earlier than formerly. By this means rest is secured for the larynx before such extensive changes have taken place as to produce cicatricial contractions, or the formation of a membranous bridge across the larynx. If, therefore, a child over five years is unable to breathe without an intubation tube at the end of from three to five weeks, or a child under four at the end of two or three weeks, tracheotomy should be resorted to and thereafter an attempt made to remove the tracheotomy tube as soon as possible. The results are probably somewhat better by this method than by practicing intubation indefinitely. With any method, however, even in the most



expert hands, there will be a small proportion of children who must wear a tracheotomy or intubation tube throughout the rest of their lives.

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## CHAPTER CXXXII

### TETANUS

Tetanus (lockjaw) is an acute infectious disease caused by *B. tetani*, discovered by Nicolaier in 1884. It is characterized by tonic spasms which involve the musculature of any part of the body, but affect particularly the muscles of the jaw. The infection is acquired almost invariably from a wound into which spores of the bacillus are introduced. The symptoms are due to a powerful exotoxin which affects the central nervous system.

**Etiology.**—*Incidence.*—Tetanus was formerly an exceedingly common disease among newly born infants, the portal of entry being the umbilical stump. In the island of St. Kilda in the Hebrides, Morgan reported in 1862 that more than 50 per cent of all newly born infants succumbed to this affection.<sup>1</sup> Similar conditions have for years existed in this country among the colored population in certain parts of the South. In Calcutta, in 1929, 15 per cent of the infant deaths were due to this disease. Since the introduction of aseptic obstetrics, tetanus neonatorum has become rare. Among 22 cases of tetanus seen in 70,000 admissions to the Harriet Lane Home, only 3 have been in newly born infants; the remainder have been in children over three years old.

*The Bacillus.*—The tetanus bacillus is an anaerobic spore-bearer. It is widely distributed in the soil in many parts of the world, particularly in agricultural regions. In the United States it is found most abundantly in the Middle Atlantic states, especially in New Jersey, Long Island and parts of the Hudson Valley. The bacillus is normally present in the intestines of horses, cattle and other herbivora, and is found to some extent in man. From 2 to 30 per cent of normal adults harbor this organism, the highest proportion being found in agricultural communities. The bacillus produces two soluble toxins—tetanolysin and tetanospasmin. Tetanolysin is an unstable hemolytic substance which apparently plays little part in the pathology of the disease. Tetanospasmin produces the severe nervous symptoms; it is this substance which is usually meant when tetanus toxin is spoken of. Tetanus toxin has a peculiar affinity for nervous tissue, *in vitro* as well as *in vivo*. Unlike many other toxins it does not produce reddening of the skin. A number of subgroups of the bacilli have been identified but the toxins they produce are identical.

*Pathogenesis.*—Although tetanus may occur when no portal of entry can be found, this is decidedly unusual. Fildes has shown that the oxidation-reduction potential of normal skin is such as to prevent germination of tetanus spores; only when a lesion is present can this occur. The primary wound may, however, appear of little consequence; it may not be infected with pyogenic organisms. Wounds

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<sup>1</sup> Gowers states that in the island of Heimaey, near Iceland, tetanus neonatorum was at one time so frequent that the population was kept up only by immigration, almost all the children dying from this cause.



most likely to lead to tetanus are (1) those contaminated with dirt, (2) puncture wounds, which provide ideal anaerobic conditions and (3) blank cartridge wounds. In the latter case the wadding of the cartridge is the source of the spores. Contused and lacerated wounds are more dangerous than incised wounds, since necrotic tissue favors the growth of the bacilli. A considerable number of cases have been caused by infected vaccines, sera or catgut. It is a mistake to suppose that tetanus bacilli are confined to the soil; the spores are readily spread by birds or insects. We know of an instance in which a splinter in the nose, acquired in the top of a tree, led to tetanus. It has followed the stings of bees and wasps.

The bacilli themselves are usually confined to the primary wound, where they proliferate and secrete toxin. Although toxin passes into the circulation and is distributed all over the body, it is apparently unable to enter the nervous system except at the nerve endings. From here it travels up the nerve trunks to the central nervous system. Since toxin starts to travel centrally from almost all nerve endings simultaneously it is apparent that the nerve cells of the shortest neurons will be reached first. Such is the explanation for the early development of trismus. This view, however, has recently been challenged by Abel.

*Immunity.*—Although agglutinins and antitoxin have been found in the blood of many normal individuals, usually those individuals who harbor bacilli in the intestine, it is doubtful if these are present in sufficient quantity to afford any practical protection. The newly born infant possesses no natural immunity, but it has been shown in instances where tetanus antitoxin has been administered ante partum that the blood of the infant contains antitoxin which must have been acquired through the placenta. Active and passive immunization will be discussed below. Although some immunity appears to be conferred by an attack, this may not persist. Rare instances of relapses and second attacks are recorded.

*Pathology.*—Tetanus produces no characteristic anatomical changes. Evidences of inflammation may be found in the primary wound, sometimes in the nerves in the vicinity of the wound. The nerve cells in fatal cases are practically normal in appearance; minute changes in the Nissl substance have been described, but these are in no way characteristic, being found in many other diseases.

*Symptoms.*—These usually begin between the fifth and twelfth day, most frequently about the seventh day. Rarely there may be pain at the site of the wound. The onset is usually insidious. It is first noticed that the neck and jaw are slightly stiff; this gradually increases. Within twenty-four hours the disease has usually declared itself. The stiffness of the jaw and neck are then very marked, swallowing may be difficult. There is usually evidence that the spasm has involved the body musculature. The spasm of tetanus is quite characteristic. Attempts at voluntary motion, cutaneous, auditory or visual stimulation initiate a paroxysmal contraction of the muscles of the body which lasts for five to ten seconds. During the spasm the body becomes as rigid as a board; the head is retracted, the back is arched, usually in the position of opisthotonos, the legs and feet extended, the arms outstretched with fists clenched and thumbs adducted. The jaws are immobile and the face assumes a peculiar, fixed expression known as the "*risus sardonicus*." The eyebrows are raised, the palpebral fissures narrowed, the angles of the mouth drawn downward and outward and the upper lip pressed firmly against the teeth.



At first these spasms are infrequent; there is complete relaxation between them and they occasion little discomfort. As the disease progresses, however, they become more frequent and may be painful; often they are initiated by the slightest stimulus. Relaxation between the seizures is then only partial, a considerable degree of tonic spasm persisting. The paroxysms may involve the respiratory muscles or the glottis with fatal results. The posture may give little idea of the intensity of the tonic spasm, for opposing muscle groups are always involved. Partial or complete relaxation of the spasm occurs during sleep or with anesthesia. Sedatives may relieve it somewhat. Sweating may be very marked in tetanus. Spasm of the sphincters with retention of urine is common. The blood may exhibit a moderate leukocytosis. The spinal fluid is usually under increased pressure but shows no cytological or chemical changes.

A number of our cases have not conformed to the typical picture described above. Trismus, although usually present sooner or later, was the first symptom in only 6 out of 22 cases. In others the symptoms were first noted in the neck, the back, the extremities or the abdominal muscles. In some cases pain was severe from the outset; in others only stiffness was complained of. The location of these initial symptoms bore no relation to that of the injury. In 5 instances the onset was with general convulsions.

The duration of tetanus in fatal cases is seldom more than three or four days; it may be less than twenty-four hours. Death results from asphyxia or from circulatory failure. There may be moderate fever rising abruptly just before death. It is characteristic of the disease that consciousness remains unaffected to the last. In cases which recover there is seldom much fever; after a few days the paroxysms gradually decrease in frequency and the tonic spasm diminishes, although it may be several weeks before they disappear entirely. Trismus is often the last symptom to go. Convalescence is usually slow and the child is often left with marked malnutrition.

A number of types of tetanus deserve special mention. Abortive attacks involving only the muscles of the jaw and neck are occasionally seen. In *cephalic tetanus* following head injuries, the incubation period is usually short; it may be as little as three days and the symptoms are usually severe. There is often paralysis of the face and there may be spasm of the pharynx (*tetanus hydrophobicus*). *Tetanus neonatorum* invariably results from umbilical infection, although the umbilical stump may appear normal. The incubation is shorter than the average for adults or older children; it commences on the fifth or sixth day. Difficulty in nursing is the symptom first noted. It usually runs a rapidly fatal course, sometimes less than twenty-four hours. *Idiopathic tetanus*, in which no portal of entry can be found, is now believed to be of intestinal origin. Cases have been reported following appendicitis or intussusception in which bacilli have been recovered from the intestinal contents. *Local tetanus*, in which the spasm is confined to the region of the wound, was exceedingly rare before the days of anti-toxin; it is now somewhat more frequent. It occurs in cases in which prophylactic immunization is inadequate. It may develop several months after the injury, and may persist for many weeks. Such cases usually recover.



**Diagnosis.**—There are few diseases with which tetanus can be confused. The history of a wound, the onset with trismus, the facial expression, and the spasm accentuated by external stimuli are quite characteristic. After the first few weeks of life, it is most unusual for convulsions to be excited by external stimuli, save in tetanus. Strychnine poisoning may simulate tetanus; trismus, however, is rare; tonic spasm between paroxysms is not present, although the contraction resulting from external stimulation may last many seconds. Meningitis may be exceedingly difficult to rule out until a lumbar puncture has been performed. The differentiation from rabies is discussed with that condition.

**Prophylaxis.**—Although every scratch or wound is a potential source of tetanus, it is not advisable to give antitoxin routinely for all minor injuries. The risk of contracting the disease is often minimal, while the danger of severe serum reactions, the discomfort of serum disease, and the practical certainty of leaving the patient hypersensitive to horse serum are serious objections. Antitoxin should be given with all blank cartridge wounds, with puncture wounds, deep lacerations and wounds in which dirt or soil has been introduced. A prophylactic dose consists of 1500 (American) units; it should always be preceded by a skin test to determine if hypersensitiveness exists. Patients who have recovered from the disease probably possess some immunity, but it may not persist.

Active immunization of man by means of anatoxin (toxin treated with formaldehyde; toxoid) has been successfully carried out by Ramon and others. Except for soldiers it is doubtful if its use will become general; among the civil population tetanus is a comparatively rare disease.

**Treatment.**—The child with tetanus should be put into a quiet dark room and kept as free as possible from all external stimuli. Unnecessary handling and bathing are to be avoided. If the trismus is severe it may be impossible to give food or fluid by mouth; fluids may be given by nasal catheter.

Sedatives should be freely used in order to diminish the spasms as far as possible. Enormous doses may be required before any effect is obtained. Bromides, chloral, phenobarbital (luminal), opiates, magnesium sulphate (intramuscularly) have all been used with success. At times a general anesthetic may be necessary. Recently, tribromethanol (avertin) has been recommended as a particularly desirable sedative and hypnotic; our experience with it has been favorable. The drug is given by rectum in aqueous solution in doses of 90 to 100 milligrams per kilogram. This dose may be repeated 4 times a day if necessary. Untoward symptoms (low blood pressure and collapse) are rarely seen. They occur when the drug is first given. In one instance we have observed a proctitis following the prolonged use of avertin. Occasionally the dose mentioned fails to produce anesthesia.

**Specific Treatment.**—Children require as much antitoxin as do adults; one should not make the mistake of giving it in proportion to body weight. Antitoxin therapy has been modified by the experiences in the World War; large and repeated doses should be employed; 20,000 (American) units may be given intramuscularly and an equal quantity intravenously for three successive days. A preliminary sensitization test should, of course, be done; the technic for this procedure is described elsewhere. The intraspinal route is often used for giving



antitoxin, but the evidence that it offers any real advantage is not convincing. A variable amount of meningeal irritation is always produced. In two of our cases severe hemorrhagic manifestations occurred, which may have been the cause of death in one instance.

Excision of the primary wound proved a valuable prophylactic measure in the World War; it may be of some benefit even after the disease is present. Wound excision should always be accompanied by a dose of antitoxin, no matter how much has been previously given.

**Prognosis.**—Before the days of specific treatment approximately 90 per cent of tetanus cases were fatal. In newly born infants, the mortality was somewhat higher, although a number of recoveries are reported in the literature. Tetanus neonatorum is still a highly fatal disease, for it is seldom recognized early enough to be treated effectively. In older children, however, a great reduction in mortality has taken place; more than half of these recover. Among 19 cases in older children seen in the Harriet Lane Home, only 6 have died.

The prognosis is less favorable when the incubation period is short, as is likely to be the case with severe wounds and wounds about the head. We have not seen recovery when the incubation period was less than eight days. The idiopathic cases in which no source of infection is found are likely to be mild and usually recover. High fever is a bad prognostic sign.

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## CHAPTER CXXXIII

### MENINGOCOCCUS MENINGITIS

This disease, formerly known as epidemic meningitis, cerebrospinal fever, or spotted fever, was recognized both in America and in Europe early in the nineteenth century. The specific organism was discovered by Weichselbaum in 1887.

**Etiology.**—The disease occurs endemically in all large cities, and also in epidemics, separated by quite long intervals. The following chart (Fig. 158) represents the occurrence of the disease in New York City during forty years. But little was seen of meningococcus meningitis until the epidemic of 1872. Since that time a certain number of deaths from epidemic meningitis have occurred each year;

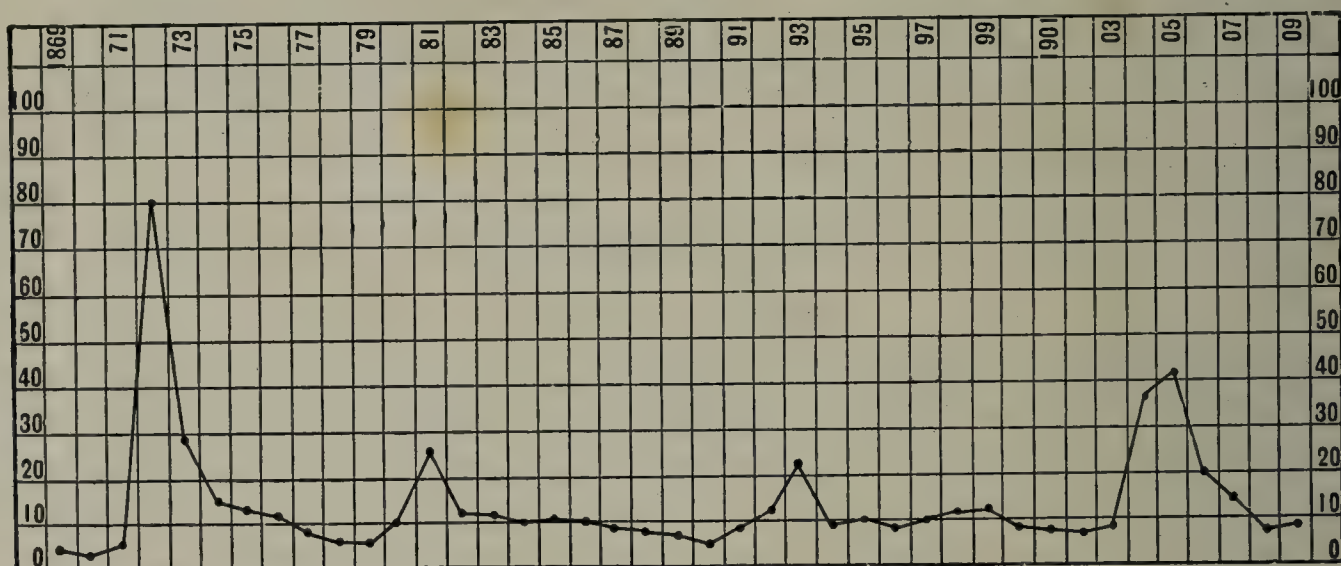


FIG. 158.—CHART SHOWING DEATHS FROM MENINGOCOCCUS MENINGITIS IN NEW YORK CITY, FOR FORTY YEARS, PER 100,000 OF POPULATION.

but there have been seen about once in ten years epidemics of greater or less severity. The most important one was that of 1904-5. After each epidemic, for two or three years, the disease is prevalent, but it occurs with gradually lessening frequency until the average incidence is reached. In remote country towns the disease occasionally appears in epidemic form, and after prevailing a few months disappears as mysteriously as it came. Epidemics usually occur in the winter and early spring, lasting for several months, generally reaching their heights in March or April and slowly subsiding as warm weather approaches.

With reference to the cause of epidemics very little is known. When the disease prevails in cities it occurs especially in crowded tenements, being relatively infrequent in private houses.

In a series of observations made by the New York Health Department the meningococcus was found in the nasal secretion of 50 per cent of patients with meningococcus meningitis examined during the first two weeks of the disease. It was found in the nasal mucus in 10 per cent of the persons in close contact with cases. The organism is sometimes found in the nose or rhinopharynx of



those who have not been ill and apparently have not been in contact with the disease. In experiments upon monkeys Flexner found the organism in the nasal mucus after animals had been inoculated by way of the spinal canal. He interpreted these observations as indicating that the nasal mucosa is a common avenue of infection and probably also a channel of elimination. Contrary to Dr. Flexner's view, however, it seems probable that the infection of the meninges almost always occurs by way of the blood stream. The degree of communicability seems very slight. In fully 70 per cent of the cases investigated in the New York epidemic of 1904-5, but one person in a household was affected, although no effort at isolation was made. We have not known the disease to originate in a hospital patient, although in New York it was for many years the practice to place patients with meningococcus meningitis in the general wards. The disease is propagated in both epidemics and in its sporadic occurrence by means of carriers. A person who has had meningitis or who has been in close contact with the disease may be a carrier of infection for many months, possibly for years. Carriers are detected by the discovery of the meningococcus in the rhinopharyngeal secretion. It is exceedingly difficult to get rid of the organisms from the nasopharynx. About 50 per cent of the cases of meningococcus meningitis occur in children under five years, and about 12 per cent in those under one year. The youngest case we have encountered was in an infant 23 days old.

The specific organism of this disease is the diplococcus intracellularis of Weichselbaum, the meningococcus. It is present in the meningeal exudate, in the cerebrospinal fluid obtained by lumbar puncture, and in some cases can be demonstrated in the blood, the lungs and other organs, sometimes in the large joints. It is almost invariably to be seen in pairs. Like the gonococcus, it is characteristically found within the leukocytes, though occurring outside as well. The meningococcus is decolorized when stained by Gram's method. Outside the body the organism is unknown. There are several different strains of meningococci that can be differentiated by means of immunological reactions. The most important are known as Types I, II, III and IV, and an additional group composed of atypical forms. Types I and III are the commonest and cross-agglutinate. The meningitis produced by each strain is more or less specific, and refractory to the serum made by means of the other strains. Accordingly, to be generally effective an antimeningococcus serum must be representative of all four strains.

**Pathology.**—In epidemic meningitis death may take place so early that the changes found at autopsy are slight. There may be essentially nothing abnormal to be found on gross inspection within the cranium, or only a serous exudate and intense hyperemia. The cerebrospinal fluid is increased in amount. If turbid, however, the microscope will show increased numbers of white cells. At the very beginning these are chiefly lymphocytes but polymorphonuclear cells soon predominate. After the third day the lesions are quite uniform. The convolutions appear flattened from pressure. The surface of the brain is covered with a greenish-yellow exudate, which is sometimes very abundant. It is generally widely distributed, but is most marked over the base. There is an increase in the quantity of cerebrospinal fluid. The ventricles are distended with turbid serum. In the meninges of the cord, lesions similar to those of the brain are seen. Rarely there



may be thrombi in any of the cerebral sinuses, or in the meningeal veins of the convexity.

Microscopical examination shows the exudate to consist of fibrin and pus cells, which infiltrate the pia mater. The superficial layers of the cortex in the inflamed areas often show minute hemorrhages. The inflammatory process frequently extends along the cranial nerves.

In patients who die after the disease has lasted two or three months, the later results of these lesions may be seen. There is usually present a chronic meningo-encephalitis, sometimes diffuse, sometimes localized. The pia mater is cloudy and thickened, and the dura is frequently adherent to the brain. Here and there are seen small, yellow, opaque patches which are the result of fatty changes in the cells and fibrin of the exudate, with some proliferation of connective tissue. The lesions are usually most marked at the base, where the thickening of the meninges and the adhesions may lead to the development of a secondary hydrocephalus.

In cases which have lasted a much longer time very marked changes are found in the brain substance. There may be generalized meningeal adhesions, with a diffuse cortical atrophy, and in addition areas of sclerosis, especially over the frontal and temporosphenoidal lobes, with which there are almost always associated marked descending degenerative changes in the cord. Such lesions are, of course, permanent, and seriously interfere not only with the functions, but also with the growth and development of the brain.

The lesions and their effects are well illustrated by the history of one of our patients who died six months after an attack. She was a bright little girl of four and a half years, and had a typical attack of meningitis of moderate severity. Convalescence was slow, but at the end of two months recovery was perfect in everything but her mental condition. She remembered nothing which she had previously learned in the kindergarten, where she had been an exceptionally bright pupil. Her mind was a blank. She was dull, listless, and her face had a vacant, idiotic expression. The special senses seemed unaffected, and her speech was retained. She died during an attack of convulsions. At autopsy the pia was everywhere thickened and adherent, while in the cortex were present the earlier changes of a general encephalitis.

The visceral lesions most frequently found are pulmonary. There may be localized or diffuse pneumonia, usually due to the pneumococcus or other organisms, rarely to the meningococcus itself. Suppurative inflammation of the joints may be present or an inflammation of the eye, usually in the form of a uveitis, both not uncommon metastatic complications. The other viscera are seldom affected.

**Symptoms.**—1. *Hyperacute Form.*—Cases of this kind are rarely seen except in an epidemic, and usually occur at its height. The onset is very abrupt, the course short and intense, and death may take place in from twelve to thirty-six hours. The following case illustrates this type: A little girl of ten years was well enough at 2 P. M. to carry a bundle of clothes a dozen city blocks. Returning home, she complained of intense headache, vomited frequently, and was so weak that she was obliged to go to bed. In a few hours she passed into deep coma, with high fever, and died at 11 P.M.

The earliest symptoms are usually intense headache, repeated attacks of vomit-



ing, and very high fever. There is great prostration and the nervous symptoms increase so rapidly that in a few hours the patient may become comatose and death occur in a short period. The temperature rises rapidly to  $103^{\circ}$  or  $104^{\circ}$ , sometimes to  $106^{\circ}$  F. A few petechial spots may be discovered over the face, chest, or extremities. There may be no rigidity, but on the contrary general relaxation. The pulse is weak, in most cases rapid, but sometimes slow and irregular. The respiration is irregular both in frequency and depth.

2. *Usual Form*.—Here, also, the onset is generally abrupt, but not so violent as in the cases just described. It may be marked by intense headache, vomiting, convulsions, delirium, chills, and fever with general hyperesthesia and rigidity. The initial temperature is from  $101^{\circ}$  to  $104^{\circ}$  F. Opisthotonos, with severe pains in the back of the neck and along the spine, and general muscular rigidity are usually present. There is often active delirium, but rarely stupor or coma. The

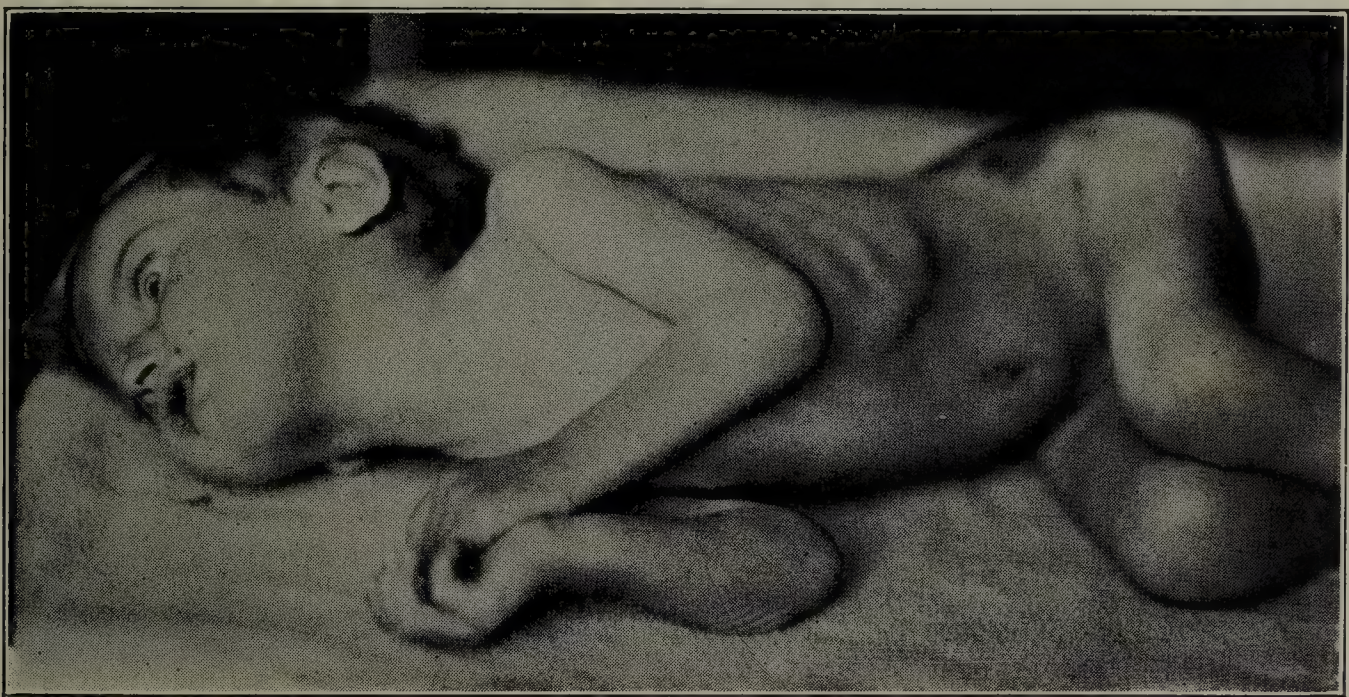


FIG. 159.—POSTURE IN MENINGOCOCCUS MENINGITIS.

pulse is generally rapid, 120 to 150, and sometimes irregular. The respiration is often slightly irregular, and it may be rapid or slow. The eruption is not so frequently seen as in the very acute cases.

As the disease progresses, the nervous symptoms often change but little from day to day for two or three weeks. There is usually moderate delirium, extreme hyperesthesia, tremor and muscular rigidity. The posture is quite characteristic (Fig. 159). Owing to the opisthotonos the child cannot lie upon the back, but rests upon the side, with arched spine and neck, and general flexion of the extremities. There is a rather rapid loss in weight, steadily increasing prostration, and a weak, rapid pulse. The bowels are usually constipated. From time to time attacks of vomiting occur. In many cases there is considerable difficulty in feeding. The duration of this form of the disease without specific treatment is from three to six weeks. The course is often marked by periods of remission and exacerbation. If recovery is to take place, the temperature gradually falls to normal and often at times it is subnormal. The mind becomes clear, and one by one the nervous symptoms disappear, the muscular rigidity being usually the last to go. Convalescence is always protracted.



In cases ending fatally, the patient usually passes into a deep stupor or coma, with extreme prostration, a slow, weak, irregular pulse, shallow respiration of the Cheyne-Stokes variety, sunken abdomen, general relaxation, finally dying from exhaustion or from pneumonia.

Occasionally the attack is much prolonged, the fever and all the active symptoms continuing from eight to twelve weeks. Emaciation sometimes becomes extreme, and with a few nervous symptoms may continue long after the fever ceases. In infants, death is often due to malnutrition. While a fatal outcome is more frequent in these prolonged cases, a few recover completely, even when marked symptoms have lasted for eight or ten weeks.

3. *Mild Form*.—The mild form is sometimes met with toward the end of an epidemic, but more often is seen as a sporadic disease. It apparently occurs more frequently in infants than in older children. The onset is usually with vomiting, but the temperature may be only 101° or 102° F. The fever may last but three or four days and the vomiting often is not repeated. The only symptoms suggesting meningitis may be muscular rigidity and moderate general hyperesthesia, and if the fontanel has not closed it generally is found tense and slightly bulging. There is a slight opisthotonos and Kernig's sign is usually present. The mind is quite clear; the child seems bright and hardly sick at all. The symptoms sometimes continue for two or three weeks before meningitis is suspected. The positive diagnosis of meningitis is made only by lumbar puncture. Occasionally the symptoms may continue for many weeks and consist only of irritability and fever with exacerbations and remissions. In children with an open fontanel tenseness of this may arouse the suspicion of meningitis, or with other children slight rigidity of the neck. The cerebrospinal fluid may be clear and contain not more than a few hundred cells per cubic millimeter with meningococci that can be demonstrated only by means of cultures. At times their detection may be impossible, but the prompt disappearance of symptoms after specific therapy renders the diagnosis practically certain.

4. *Chronic Form*.—Owing sometimes to the extent, sometimes to the position of the lesions, the disease does not subside at the usual time, but nervous symptoms continue after the temperature and most of the other constitutional symptoms have passed away. These cases are chiefly of the basilar type, and often lead to the development of chronic basilar meningitis with secondary hydrocephalus. They are more fully considered in the next chapter.

5. *Atypical Forms*.—These are not so very uncommon both in epidemics and sporadically. There may be a meningococcus septicemia without any evidence of meningitis. This may give rise to fever and other constitutional symptoms and, as a rule, petechiae in the skin. The organisms are recovered by blood culture. Such cases may continue for weeks if untreated. Sometimes there are joint symptoms or other metastatic manifestations. The condition may subside or a meningitis develop at any time. The response to intravenous antimeningococcus serum is usually prompt.

*Onset*.—One of the most striking features of this disease is the abruptness with which it develops. Occasionally there are indefinite symptoms for a day or two before active symptoms begin: but in the great majority not only the day, but the



hour of the onset is definitely marked. The most frequent initial symptoms are the simultaneous occurrence of severe headache and vomiting, followed by high fever and marked prostration. The vomiting is usually repeated, projectile, and has no relation to meals. Convulsions occurred in the beginning of 30 per cent of our cases. Occasionally a decided chill is seen. After twenty-four hours acute general pains and hyperesthesia are usually present, together with rigidity of the muscles of the neck and extremities, giving rise to opisthotonos and muscular contractions.

*Skin.*—Eruptions upon the skin vary much in frequency in different cases and in different epidemics. The most characteristic one is the appearance of small punctate hemorrhages, resembling flea bites; they are not numerous, but may be found on almost any part of the body, most frequently upon the extremities, the upper part of the chest, and neck. In our experience they have been present in about 15 per cent of the cases. Sometimes larger hemorrhages are present. We have twice seen a very extensive purpuric eruption with hemorrhagic areas from half an inch to three inches in diameter over the face, buttocks, and extremities. This eruption belongs to the early stage of the disease and is rarely visible after the third or fourth day unless unusually extensive. In some cases a general erythema is present; in others, an eruption closely resembling measles. Herpes upon the lips and face is common in older children, but is rare in infants. Bed sores are very common in protracted cases. They are found over pressure points—the trochanters, the malleoli, and the sides of the head; in several instances the ear has been the part affected.

*Nervous System.*—Headache is a frequent initial symptom and is usually severe; it is more often frontal than elsewhere, and may be associated with vertigo. There are acute pains in the back of the neck, along the spine, and marked general hyperesthesia, which is often so intense that any movement of the body causes agonizing cries. This is one of the most striking symptoms of the disease, and may continue throughout the acute stage. The mental state varies much in different cases. Delirium is frequent in the early stage of the severe form; it is usually active, sometimes maniacal. After delirium, dullness or apathy ensues, giving place to great irritability when the patient is disturbed. Convulsions are not uncommon early, but are seldom repeated in the course of the disease except toward its close. There is rarely continuous stupor or deep coma except toward the end of fatal cases. In many cases with high temperature and quite severe symptoms, after the subsidence of a short early stage of excitement or delirium, the mind remains perfectly clear throughout the attack. In these circumstances an erroneous diagnosis is often made, particularly if the physician has not observed the case from the beginning.

Tonic spasm of the various muscular groups is one of the most characteristic features of this disease and is seldom absent. Like the hyperesthesia it is persistent. The rigidity and contraction of the muscles of the neck and back produce cervical or general opisthotonos; cervical opisthotonos is most marked with lesions chiefly at the base, and may be wanting in the rare cases when the lesion is almost entirely at the convexity. Tonic spasm of the extremities usually causes general flexion of the thighs, legs, and arms. Late in the disease this may be replaced



by complete extension of the lower extremities, with foot drop. The tonic muscular spasm gives rise to Kernig's sign. Brudzinski's sign is frequently present. Muscular rigidity is one of the most constant symptoms of this disease and one of the last to disappear. It may be absent in the early stage of the hyperacute cases, and very late in fatal cases, when there may be general relaxation. Other nervous symptoms frequently present are ankle clonus, muscular tremor, especially of the hands, and paralysis, which may be facial, monoplegic, or hemiplegic. The knee jerks are usually increased.

*Eye and Ear.*—The pupils in the early stage are generally contracted; they are often unequal. Ocular paralyses are not so frequent or so marked as in tuberculous meningitis. The same is true of the changes in the optic disk, although

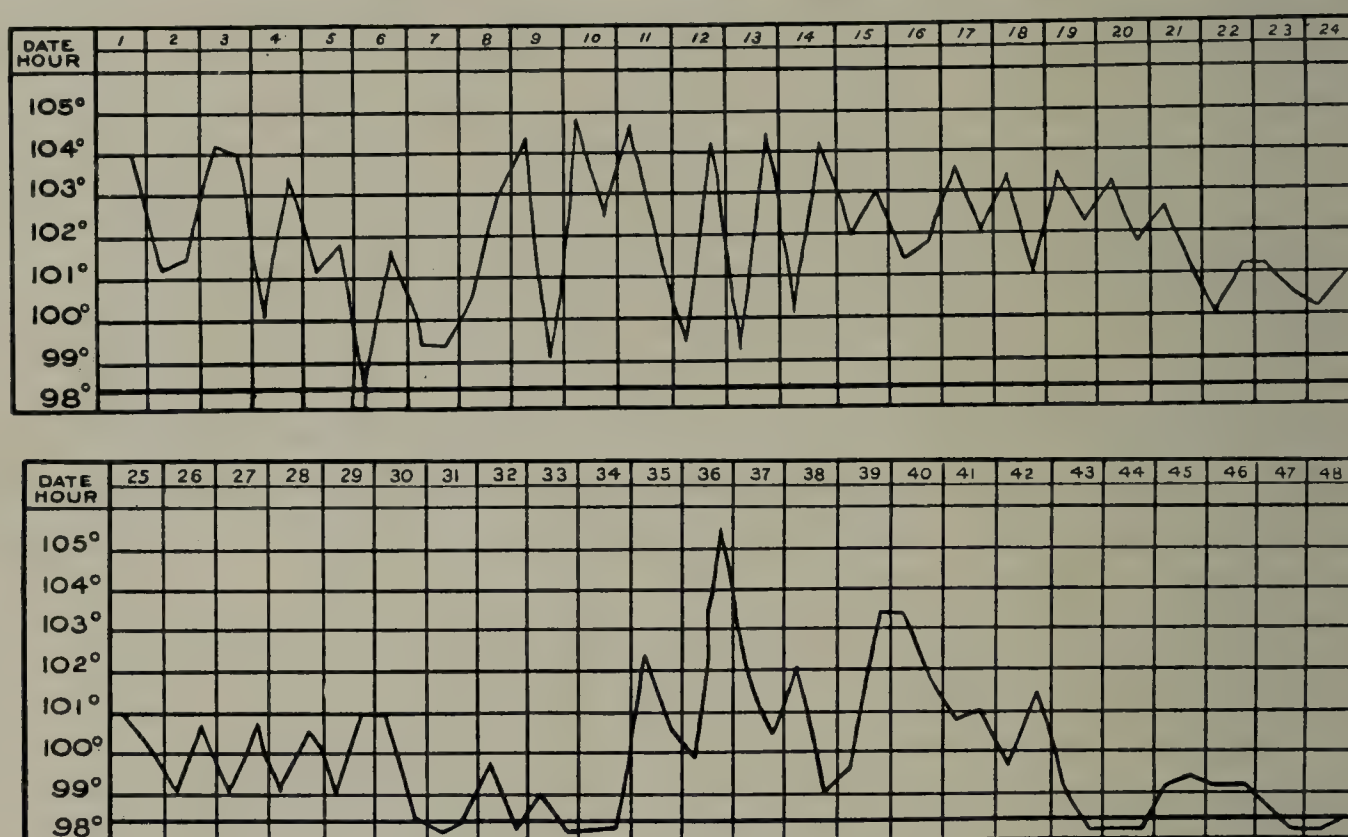


FIG. 160.—MENINGOCOCCUS MENINGITIS.

Recovery without serum treatment. Fairly typical chart of prolonged case, showing remissions and exacerbations. Patient three and one-half years old; unconscious, blind, and deaf for two and one-half months; complete recovery.

these vary much in different epidemics. There may be congestion of the fundus, retinitis, or optic neuritis. In some epidemics such changes have been observed in fully half the cases. In that of 1904-5, in our hospital cases, they were rarely seen, and then were but slightly marked. Conjunctivitis is frequently present and may be severe. There may be choroiditis and sometimes uveitis leading to complete destruction of the eye; usually this is unilateral. Early deafness is due to an extension of the inflammatory process into the labyrinth; it is generally bilateral, and usually permanent. Acute otitis media occurs as a complication, and the meningococcus is occasionally found in the exudate.

*Fever.*—This disease is usually attended by high fever, but the curve is apt to be an irregular one and show wide variations. The temperature is nearly always high at the onset; in the hyperacute cases it may reach 106° F. or higher. The usual range during the disease is from 100° to 105° F. (Fig. 160). Sometimes it is steadily high; not infrequently a few days after a sharp acute onset it falls



nearly or quite to normal and remains there for several days. Cases seen in this afebrile period are most difficult of diagnosis. This stage may be followed by another sharp rise, and afterward continuous fever. Periods of remission and exacerbation in the temperature are seen in a large proportion of the prolonged cases. Often it becomes subnormal. The temperature may bear no relation to the severity of the other symptoms. Its course is greatly modified by serum treatment.

*Respiration* is disturbed very early in the disease, when it is often irregular and may be slow or rapid. Throughout the greater part of the attack it may be nearly normal. Occasionally it is of the typical Cheyne-Stokes variety.

*Pulse*.—Throughout the greater part of the disease the pulse is rapid. In the early stage it is often weak, and sometimes irregular. The average frequency in young children is from 130 to 150. A slow, irregular pulse is occasionally seen late in the disease in patients who are in deep coma.

*Blood*.—A leukocytosis is present in nearly all cases. The average is from 15,000 to 30,000. The increase is chiefly in the polymorphonuclear cells, which usually form from 80 to 85 per cent of the leukocytes. Blood cultures made early in the disease have in some cases shown the presence of the meningococcus.

*Digestive System*.—Vomiting is one of the most frequent symptoms of onset but rarely persists throughout the attack. Late in the disease it may be most troublesome. As a rule constipation is present. The tongue is coated, dry, glazed, sometimes covered with sordes. In a small proportion of cases jaundice has been observed. On account of the loss of appetite, great irritability, delirium, and stupor, the greatest difficulty is often experienced in feeding these patients. Early in the disease the abdomen is natural; in the late stage it is often scaphoid.

*General Nutrition*.—This is impaired in nearly all cases. There is a progressive wasting, greater than would be explained by the disturbance of digestion. In the protracted cases it may be extreme. Infants and young children often die of inanition long after the active symptoms of the disease have subsided.

Other symptoms of importance are: a tense, bulging fontanel, in infants rarely absent early in the attack, but often wanting in the late wasting stage; incontinence of urine and feces, or retention of urine; occasionally swelling of some one of the large joints is seen.

**Course, Duration, and Termination**.—Excluding the hyperacute cases in which death occurs very early, the usual duration of active symptoms in cases not treated with serum used to be from three to six weeks. Of 350 cases recovering without serum, the disease lasted less than one week in 3 per cent; in 50 per cent it was five weeks or longer. Some very protracted cases terminate favorably. We have seen one child recover completely after 84 days of fever, and another after 102 days. Most of the prolonged cases are marked by periods of exacerbation and remission. Not until the temperature has been normal for several days, the mind has become clear, and the hyperesthesia and rigidity have entirely disappeared, can we consider convalescence as established. Recovery is slow, and it may be many months before the child is quite well. In 220 cases receiving serum treatment the average duration of active symptoms after the first injection was eleven days.

In fatal cases, death may come early in coma, convulsions, or with symptoms



of circulatory failure. It may occur in the middle period from complications, most frequently pneumonia, or the terminal stage of the disease may be seen with extreme wasting.

**Complications and Sequelae.**—The most dreaded complication and the most common in infants and young children is obstruction of the foramina or cisternae at the base of the skull or occasionally of the aqueduct, brought about by a very thick exudate which later may become organized. A rapidly developing hydrocephalus results. The symptoms are headache, stupor, repeated vomiting, choking of the disk and distention of the retinal veins. These symptoms appear in the course of the disease and even during active treatment with serum. The patients, instead of improving, become worse with a continuation of the fever. The amount of cerebrospinal fluid obtained by lumbar puncture grows progressively less until only a few drops pass through the needle and these very slowly. A large amount of fluid, however, can be removed by puncture of the ventricles through the fontanel. This ventricular fluid frequently contains viable organisms when there are none in the fluid obtained by lumbar puncture. If the obstruction is not overcome by serum treatment, death occurs from the infection, or the patient passes into a state of chronic meningitis with hydrocephalus.

Another not uncommon complication to be watched for in severe protracted cases is deafness due, as already stated, to the extension of the inflammation into the inner ear. It is almost always bilateral, complete and permanent. Often one is in doubt for several days, particularly when recovery is beginning, whether the failure of the patient to respond to spoken words is due to deafness or to the stupor characteristic of the disease. Otitis media has already been mentioned.

In 4 to 5 per cent of cases, according to Jochmann, an ophthalmia develops. It manifests itself as a uveitis or purulent choroiditis and results usually in profound injury, leading to loss of vision. It is embolic in origin and consequently almost always affects only one eye. In severe cases, especially those in which an obstructive kind of hydrocephalus develops, choking of the disks takes place. If the hydrocephalus is of long duration, optic atrophy gradually appears with partial or, more rarely, complete loss of vision. A nonspecific conjunctivitis is a common occurrence. In comatose patients lying with the eyes open, a trophic affection of the cornea may develop unless precautions against drying are taken. If neglected, it may lead to ulceration and perforation.

Another, not very rare, complication of septicemic origin is arthritis. It occurs comparatively early in the disease, generally about the fifth or sixth day. The larger joints are usually the ones affected and several may be involved. The evidences of involvement are swelling, redness, tenderness, pain on motion and the signs of increased formation of fluid within the joint. The fluid obtained by aspiration is turbid, sometimes purulent and may or may not contain meningococci. The inflammation is transitory, although the appearance of the aspirated fluid might not lead one to think so, and disappears spontaneously after a few days.

Other complications are pneumonia and bed sores. As already mentioned, the pneumonia is only rarely due to the meningococcus itself. Bed sores develop only in protracted cases.



There may be perfect recovery so far as physical functions are concerned, but the child be left mentally deficient. In some cases the defect is so slight as not to be evident for several months or even years; in others the mental faculties are entirely lost. There may also be various types of paralysis—strabismus, facial paralysis, monoplegia, hemiplegia or diplegia, and often contractures, which are sometimes temporary, but apt to be permanent. As a late result epilepsy may develop. Very rarely injury to the spinal cord may be caused, and loss of control over the bladder and the rectum, anesthesia, and trophic ulcers may result.

**Diagnosis.**—Lumbar puncture is the only accurate means of diagnosis we possess. The quantity of fluid which may be removed at one time varies from a few drops to three or four ounces. During the first day or two it is usually slightly cloudy; sometimes it is very turbid and it may be thick and purulent. As the disease progresses the pus cells gradually diminish and in favorable cases disappear, but may reappear with an exacerbation of the symptoms. These changes are greatly modified by serum injections.

The presence of many leukocytes in the cerebrospinal fluid indicates meningitis, which may be due to meningococci, or possibly to pneumococci, influenza bacilli, staphylococci or streptococci. The organisms can be identified by smears from the sediment of the fluid obtained after standing or after centrifuging, and by cultures, which should be made immediately after the fluid is withdrawn. In meningococcus meningitis, diplococci are found within the pus cells, and some are also free in the fluid. The organisms are usually numerous in acute cases. At first they may be largely extracellular but they become intracellular, especially after serum treatment, when they stain poorly and after a few days can no longer be demonstrated (see table on pp. 802 and 803). In some cases of undoubted meningococcus meningitis no organisms can be found either by smear or culture. Exceptional cases are met with in which early punctures give a clear fluid and no organisms are found; a few days later the fluid may become turbid and the organisms abundant. The meningococcus may persist for a long time. In one of our cases not treated by serum it was present on the ninetieth day.

The early diagnosis of cerebrospinal meningitis by symptoms alone presents peculiar difficulties. The most valuable for diagnosis are: a sudden onset with intense headache, vomiting, high temperature, prostration, a petechial eruption, marked rigidity of the neck and extremities, with hyperesthesia, great irritability or early stupor. Later, four symptoms are rarely wanting—persistent hyperesthesia, muscular rigidity of the neck and extremities, Kernig's sign and fever. The mind in many cases remains perfectly clear; in others there is delirium, but seldom continuous, deep coma. The very mild cases are apt to be overlooked; they are recognized only by lumbar puncture. This also serves to distinguish meningitis from pneumonia and many other diseases with cerebral symptoms.

It is sometimes difficult to distinguish meningococcus meningitis from the tuberculous form and from acute poliomyelitis with meningeal symptoms. The fluid in meningococcus meningitis is usually turbid and contains many cells of the polymorphonuclear variety; in tuberculous meningitis the fluid is clear and the cells found are nearly all lymphocytes. The characteristics of tuberculous meningitis are a gradual onset with indefinite symptoms, low temperature, per-



sistent drowsiness, irregularity of pulse and respiration, absence of active delirium, late coma, less marked hyperesthesia and rigidity, a duration seldom over three weeks from the beginning of definite cerebral symptoms, and an invariably fatal termination.

Under the discussion of the diagnosis certain practical points may be emphasized. A petechial eruption should always make one think of epidemic meningitis. The petechial eruption often precedes the meningitis by hours or days. If the signs of meningitis are present, a petechial eruption is strong presumptive evidence that the meningitis is meningococcic in origin. McLean and Caffey were able to demonstrate the organisms in smears made from the skin lesions in more than 80 per cent of purpuric cases in which skin lesions were caused by meningococcemia. In several instances this diagnostic test revealed a meningococcemia before the blood culture had grown and before any change had taken place in the spinal fluid. Herpes labialis, though exceedingly rare in infants, ought automatically to suggest the possibility of meningococcus meningitis. In infants especially the symptoms may be most deceiving. Rigidity may be entirely lacking or limited to the neck and so slight in degree as easily to be overlooked. Often, in the infant, a tell-tale bulging of the fontanel will be found. Often, though relaxed, such infants will be found to have hyperactive reflexes and to be extremely hyperesthetic. Hyperesthesia may be the only physical sign and in experienced hands may alone lead to the diagnosis of meningitis. We recall an infant who lay in the Harriet Lane wards for a week with unexplained fever, until hyperesthesia and a slight increase in the tendon reflexes were discovered. Lumbar puncture yielded a purulent fluid filled with meningococci. We have also seen an older child in whose case the sole history was of vomiting of some weeks' duration. There were no signs of meningitis. The case was regarded as one of neurotic vomiting. When it was observed, however, that the vomiting was projectile and that slight fever was present, a lumbar puncture was performed and turbid fluid filled with meningococci was obtained. Of all the kinds of meningitis, meningococcus meningitis is the one in which the sensorium is most often preserved even though the physical signs of the disease may be extreme. It is common to see a patient lying in extreme opisthotonos, scarcely able to move, but answering questions in a perfectly intelligent and intelligible manner. The retention of the faculties in severe meningococcus meningitis is often so striking as to be an aid in recognizing the nature of the meningeal infection. A turbid or purulent cerebrospinal fluid which seems devoid of organisms is a more common finding in epidemic meningitis than in any other form of pyogenic meningitis. Occasionally, in influenzal meningitis no organisms can be found for several days in the spinal fluid though the latter is full of pus cells; rarely, and only for a short time, can organisms not be found in the spinal fluid in pneumococcus and streptococcus meningitis. If the fluid in a case of meningitis is purulent and no organisms can be demonstrated on repeated examination, the presumption is that the case is one of meningococcus meningitis. Sometimes meningococci can be obtained from the ventricles when not elsewhere. If the meningitis is of a pyogenic variety and has persisted for two or more weeks, it is probably meningococcus in nature. Influenzal meningitis and occasionally staphylococcus meningitis may, however, be of long duration and even end in recovery.



**Prognosis.**—The mortality is much higher in epidemics than when the disease occurs sporadically. It is usually greater at the height of an epidemic and lower at its close. The average mortality before the serum treatment was about 70 per cent. We know of no recorded epidemic in which the mortality was less than 50 per cent. In the last year of the 1905 New York epidemic, of 1780 cases tabulated by the Department of Health the mortality was 76 per cent. Of 59 cases treated in our hospital wards in the same epidemic the mortality was 80 per cent, nearly all these patients being under three years of age. Of 24 cases under one year only one recovered. Of the cases seen in private practice, largely in older children, the mortality was 50 per cent. None of these had serum treatment. Not all of those who do not die are to be classed as recoveries, for in fully 25 per cent serious sequelae remain. The prognosis in patients treated with serum is discussed below.

**Treatment.**—*Serum treatment* is far more effective in controlling this disease than any other measure thus far proposed. The serum is obtained by immunizing horses, at first with heat-killed vaccines, later with living cultures of various strains of meningococci. Its action is partly antitoxic, partly antibacterial. It is used as follows: After withdrawing by lumbar puncture all the fluid that will flow readily, under strict aseptic precautions, the serum, warmed to body temperature, is introduced by gravity without removing the needle. In some exceedingly sensitive patients the administration of a general anesthetic may be necessary. The injection should be made slowly, occupying several minutes.

The initial dose of the serum now used is 15 to 20 c.c. for infants, and 25 to 35 c.c. for children from two to twelve years old. The amount injected should never exceed the amount of fluid removed. The dose is usually repeated in twelve hours and a daily dose repeated thereafter until three or five have been given. Continuation of the treatment will then depend on the reaction of the patient. The first goal is to force the disappearance of the organisms from the spinal fluid. The rule is that serum treatment should be continued for at least three days after it has become impossible to find meningococci in the spinal fluid, either by smear or culture. The next goal is to bring to pass a characteristic change in the spinal fluid itself. The fluid should show signs of clearing—under serum treatment it will always remain yellow—the total number of cells should fall to not more than 200 to 300, and lymphocytes should predominate over polymorphonuclears. While these changes in the spinal fluid are in progress a favorable turn should be noted in the patient's condition. The temperature should fall, though rarely reaching normal; the stupor should lessen, the mind emerge to a more nearly normal state, and the muscles should show signs of relaxation. In determining when to stop treatment one should be guided by the response of the spinal fluid and by the reaction of the patient as a whole, but the changes in the spinal fluid furnish the better indication. The reaction of the patient as a whole, when considered by itself, is an untrustworthy guide to the cessation of treatment. In general it is better to err on the side of giving serum for too long, rather than too short a time. When serum is continued for too long, the temperature rises again, and the rigidity of the neck and extremities and the Kernig sign become greatly aggravated. It is often a difficult question to decide whether the disease is becoming



worse, in spite of the treatment, or whether the patient is being overtreated. When the latter is suspected, it is wise to inject serum on alternate days. Then it becomes apparent that the treatment is the cause of the aggravation of the symptoms, because on the days between treatments, the fever shows a tendency to fall and the nervous symptoms to abate. If the disease is progressing, the spinal fluid should reflect it by a rise in the total number of cells and a great relative increase in the polymorphonuclears. The continuance of a relatively high lymphocyte count

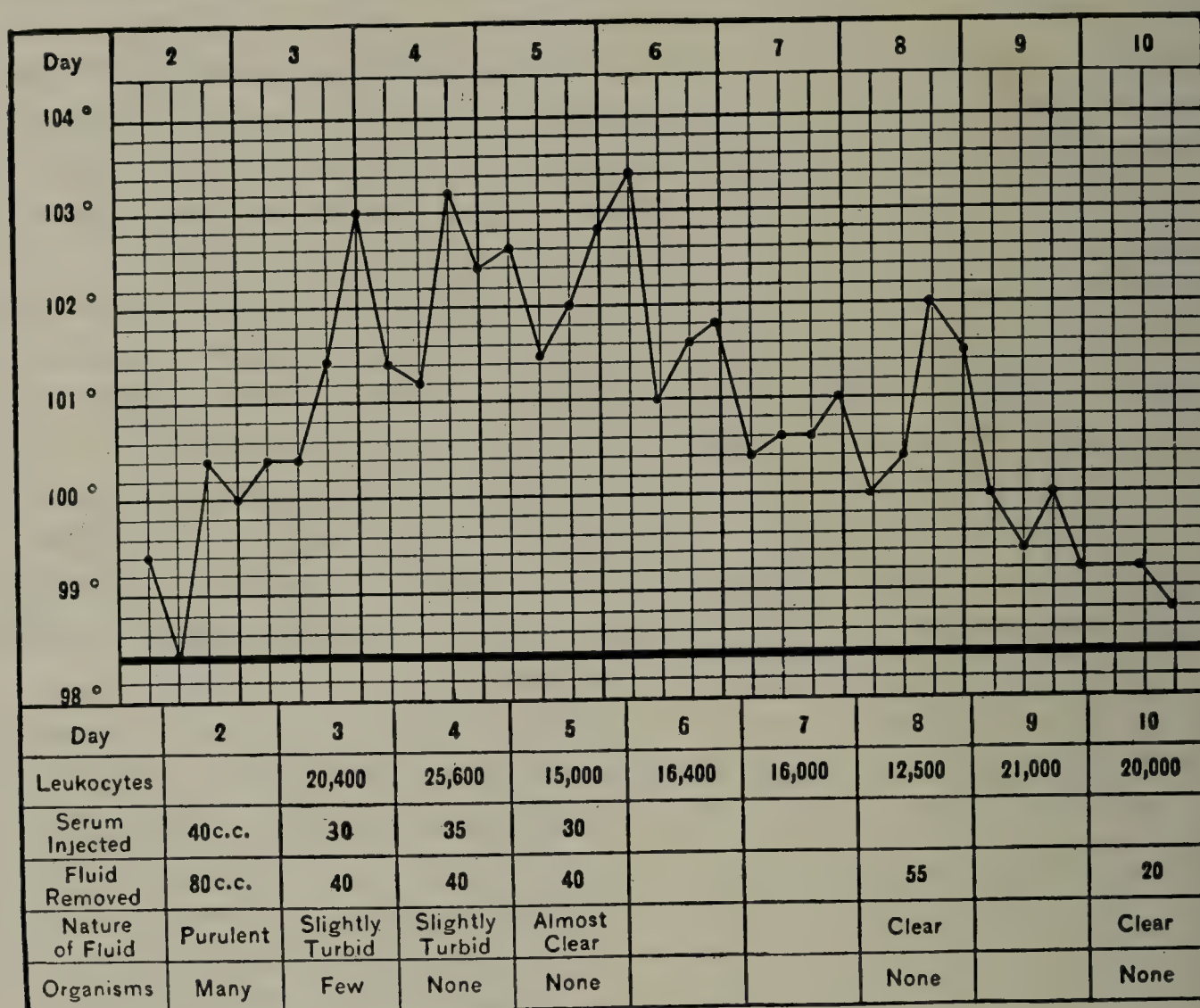


FIG. 161.—MENINGOCOCCUS MENINGITIS TREATED BY SERUM.

Infant seven months old, Babies' Hospital: twenty-four hours ill; intense prostration; respiration, 80; signs of pulmonary edema; general relaxation; stupor; profuse hemorrhagic eruption. First fluid, purulent; amount removed, amount of serum injected, and the changes in the fluid shown in the chart. Immediate improvement in symptoms after first injection. Subsequent symptoms typical. A rise in temperature on the eighth day and the increase in leukocytes on the ninth and tenth days suggested relapse; but as the fluid was clear and no organisms could be found in smears or by culture, no more serum was given; complete recovery.

in the spinal fluid is strong evidence in favor of overtreatment as opposed to exacerbation in the disease itself. It is important to appreciate that the cells in the spinal fluid will never fall to normal and the fluid never become water-clear, or the temperature remain normal as long as serum is being given and, consequently, it is wrong to look for the complete restoration of the normal state, either in the spinal fluid or in the individual as a whole, as the goal to be reached before bringing serum treatment to an end. The indications for further injection are: continuance of marked nervous symptoms, persistence of leukocytosis and of great numbers of polymorphonuclear cells in the cerebrospinal fluid, even though no organisms are found in smears and there is no growth from cultures. If the



fluid is clear, if no more organisms can be found, if the number of cells is falling rapidly, even though they may still be two or three hundred per c.mm., if the nervous symptoms and signs all show improvement, it is not usually necessary to continue injections, even though there may still be fever. We have seen a number of instances in which fever and an increase in cells (chiefly mononuclear) in the cerebrospinal fluid have persisted as long as injections were made, but ceased immediately when they were discontinued. Even in the mildest cases it is wise to give at least four doses on successive days. The serum arrests the inflammatory process by destroying the organisms which produce it. To accomplish this a sufficient dose must be given, and given early, before important inflammatory changes have taken place.

In cases in older children seen very early there may be an advantage in giving serum intravenously as well as by intraspinal injection.

An immediate effect of the injection is seen in the cerebrospinal fluid. There is often first an increase followed by a marked reduction in the number of polymorphonuclear cells. The number of meningococci is greatly reduced. After the first injection they stain with difficulty, and after a second injection it is often impossible to grow them, although they are usually present in small numbers. The effect on the symptoms is often striking. There is a marked reduction in the temperature, which may amount to three or four degrees in twenty-four hours, and it may not rise again. The stupor and delirium often diminish rapidly, and soon disappear. Improvement is also seen in the patient's general condition, pulse, and respiration. The last symptom to be affected is usually found to be the rigidity of the neck and extremities.

Intraspinal injections are not wholly devoid of danger. A moderate degree of shock following the procedure is quite common. The child's head should be lowered and he should be closely watched for half an hour or more. In rare instances more serious symptoms are seen, usually in the nature of an acute failure of respiration. Alarming symptoms generally come on quite abruptly with little warning, and unless promptly recognized and energetically treated death may follow. In some instances shock is produced by the administration of cold serum; in other cases it may be attributed to the sudden change in intracranial pressure, but in still others the mechanism is entirely obscure. If the symptoms develop while serum is being injected, the funnel should be lowered and some of the fluid siphoned out of the canal. Epinephrine should be given intramuscularly and artificial respiration employed energetically. We have seen but 2 fatal results, but in several instances it has been necessary to use artificial respiration for fifteen or twenty minutes before normal respiration was established. It is evident that the greatest care should be used in injecting serum and that the possibility of the development of serious symptoms should always be kept in mind.

The striking reduction in mortality following the introduction of serum therapy is indicated by the more recent statistics of J. B. Neal in New York City. The mortality in the first year of life was 44 per cent, in the second year 28 per cent and between two and five years 16 per cent. This indicates what may be expected with serum treatment under favorable conditions. The mortality in young infants, however, is still distressingly high.



The results with injection of serum are greatly modified by the time of injection, as shown by the following table:

TABLE LII  
MORTALITY IN RELATION TO TIME OF SERUM INJECTION

Time of Injection	Flexner (All sources, chiefly U.S.), Per Cent	Netter (France), Per Cent	Dopter (France), Per Cent
First to third day.....	14.9	7.1	8.2
Fourth to seventh day.....	22.0	11.1	14.4
After the seventh day .....	36.4	23.5	24.1

The effect on the course and duration of the disease is no less marked than that upon the mortality. The duration of acute symptoms is very much shortened by serum treatment and in about one-fourth of the cases the disease terminates by crisis. This is more often seen in cases injected early, although it is observed in some injected as late as the fourth week. The infrequency of complications and sequelae is also noteworthy. Not only do patients recover, but they recover quickly, and in most instances completely.

Relapses occur in a small proportion of the cases. They are due to the fact that the organisms have not been entirely destroyed by the serum. They are usually indicated by a rise in temperature, an increase in the leukocytosis, and an aggravation of the nervous symptoms. They are to be treated like a primary attack, daily injections being repeated so long as organisms and symptoms persist.

Very little improvement is to be expected in patients who have passed the febrile stage and who are suffering chiefly from the effects of distention of the ventricles due to a chronic basilar lesion. The most unpromising early cases are those of the fulminating type, which have usually advanced so far before serum is given that recovery is impossible. Unpromising also are cases in which a very thick purulent fluid is present which can hardly be withdrawn through the needle. The amount which can be removed is usually very small. The diffusion of the serum in the canal is difficult. In such cases an attempt may be made to irrigate the spinal canal with a warm sterile salt solution before injecting the serum. This measure is not often successful.

In some instances, particularly with infants, it is advantageous to inject the serum directly into the ventricles. This may be done through the fontanel or with older children after trephining. The indications for this are severe fulminating cases, when the fluid is very thick or when only a few drops can be obtained by lumbar puncture; also with beginning hydrocephalus and when, owing to the necessity for frequent treatment, the lumbar region has become inflamed or there has been infection of the skin. We have used ventricular puncture frequently; there can be no doubt that it is at times life-saving. Cisterna puncture has the advantage of bringing the serum into immediate contact with the inflammatory exudate. It may be used alternately with lumbar puncture. Fluid for examination may sometimes be obtained by this method when lumbar puncture



has been unsuccessful. G. M. Lyon has recently employed a method of treatment that promises to reduce the mortality—particularly in young infants. This consists in complete substitution of the cerebrospinal fluid by serum. Needles are introduced simultaneously into the ventricle and lumbar region (the procedure may be carried out unilaterally or bilaterally) and as fluid is removed from the lumbar region, serum is allowed to flow into the ventricle by gravity. The serum is marked with dye; when this appears in the lumbar fluid the syringes are disconnected, the needles being allowed to drain before withdrawal. By this means it is possible to introduce larger quantities of serum (60 to 100 c.c., depending upon whether one or both ventricles are used), and more infected fluid is withdrawn

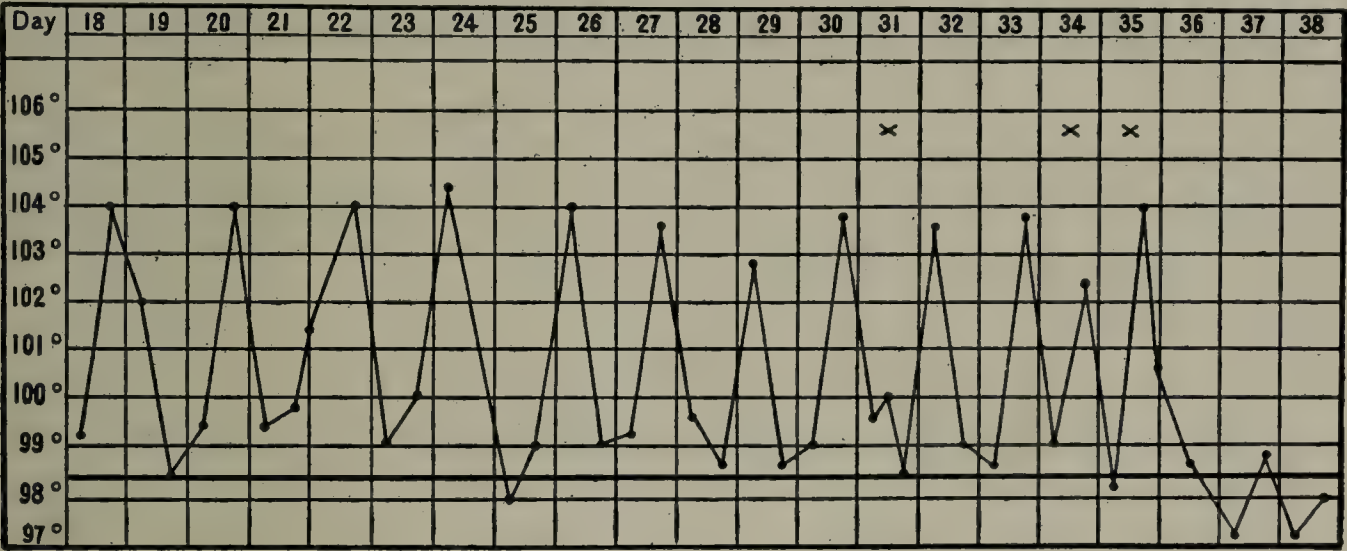


FIG. 162.—MENINGOCOCCUS MENINGITIS.

Late injection of the serum, prompt effect; complete recovery. Boy, eleven years, St. Vincent's Hospital, New York. Early symptoms obscure, and on account of swelling and pain in joints diagnosis of rheumatism made; cerebral symptoms not marked. First lumbar puncture made on thirty-first day and meningococcus found. Serum injected on the thirty-fourth and thirty-fifth days. Rapid fall in the temperature followed by cessation of all symptoms and complete recovery.

at an early date. The procedure may be repeated in forty-eight hours. Fluid is withdrawn for examination, however, at shorter intervals. Our experiences with this method in two cases have not been favorable.

After the infection has been overcome, it may be advisable to continue to withdraw cerebrospinal fluid at intervals for a few days and even for two weeks or more. The irritation of the inflammatory process at times seems to have disturbed the relationship between the secretion and the absorption of cerebrospinal fluid. The indications for puncture are irritability, sleeplessness, vomiting, and a bulging fontanel. The symptoms are usually relieved at once by the procedure but may return again in a few hours.

Some cases are seen that run their course entirely uninfluenced by antimeningococcus serum, though this may be used repeatedly and in large doses. The meningococcus in these circumstances usually belongs to some unusual strain which is not represented in the strains used to produce the serum.

It is wise to use a serum which will agglutinate the meningococcus concerned. If the serum does not, and if no favorable effect follows its use, another should be tried. Agglutination probably does not measure accurately the efficiency of a serum but it is the best estimate of this that we possess at present. Meningitis



caused by other organisms closely related to the meningococcus but not identical with it is uninfluenced by antimeningococcus serum.

In any case suspected to be meningococcus meningitis, lumbar puncture should be made as early as possible. If the fluid obtained is purulent or only slightly turbid, serum should be injected at once. If the fluid is clear, the disease is probably not meningococcus meningitis, and one may wait for a bacteriological report.

*General Measures.*—An ice-cap should be applied to the head, and at times an ice-bag along the spine. Treatment otherwise is directed toward the symptoms of the disease. Severe pain requires morphine or codeine, sometimes in large doses. For other nervous symptoms, such as delirium and sleeplessness, bromides and barbital derivatives may be given, or warm sponge or tub baths. Stimulants are indicated by a weak, rapid, and irregular pulse. Caffeine and digitalis may be employed.

The nutrition of the patient is important. Feeding is often difficult, and gavage may be advantageously employed. Bed sores should be prevented by cleanliness, and frequent changing of the patient's position. Retention of urine may require the use of the catheter.

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## CHAPTER CXXXIV

### CHRONIC BASILAR MENINGITIS

It was first pointed out in 1898 by Still that this disease is usually due to the diplococcus intracellularis; in other words, that it is a chronic form of meningococcus meningitis. Chronic basilar meningitis is most frequently seen after epidemics of meningococcus meningitis, but it is occasionally met with at other times as a sequel of a sporadic case. It occurs after an acute attack, when the basilar lesion persists and becomes chronic. As acute meningococcus meningitis in infants is usually fatal if the attack is severe, it follows that the chronic form is seen only after the mild attacks. It is chiefly for this reason that the early symptoms often are not recognized as those of meningococcus meningitis. The patient frequently does not come under observation until all acute symptoms have passed away, the persistent opisthotonos being the chief feature of the case.

There is also seen in children a chronic basilar meningitis of syphilitic origin. A number of such cases have come under our observation. We have seen one case due to *B. proteus*, the infection originating at the time of birth.

**Pathology.**—This process is usually limited to the base of the brain. The pia mater is thickened about the interpeduncular space, also over the medulla, pons, and cerebellum. It may be adherent to the inner surface of the dura. The foramina of Magendie and of Luschka are obstructed, or the cisternae at the base are more or less obliterated. As a consequence of interference with the absorption of cerebrospinal fluid, hydrocephalus results. Rarely, pus may be found in the ventricles. There may be cyst formation at the base of the brain due to the accumulation of fluid in one of the cisterns of the pia. In such circumstances the cerebellum is often compressed by the fluid. The cranial nerves may also be affected.

**Symptoms.**—The onset is usually gradual, although in most cases there can be obtained a fairly distinct history of an early active period. The most prominent symptoms are cervical opisthotonos, moderate hydrocephalus, and usually general muscular rigidity. The opisthotonos is often extreme and is greater than is seen in any other disease. If placed upon his back the body of the child often touches the table only at the occiput and the sacrum. The head is usually somewhat enlarged, but never to the degree seen in primary hydrocephalus; the fontanel bulges, and the sutures are separated. These symptoms are due to an accumulation of fluid in the lateral ventricles. The rigidity of the extremities is very great and in most cases constant; the legs and feet are usually extended, while the forearms are flexed and the hands clenched. All the reflexes are greatly exaggerated. There is rarely coma, but mental dullness alternating with periods of great irritability in which general convulsions may occur. Vision may be impaired or wanting entirely. The fact that in most of the cases optic neuritis is absent is of some value in differentiating this disease from tumor. Nystagmus is



often present and attacks of vomiting occur without evident cause. There is no fever except for a few days at a time during acute exacerbations. Fluid obtained by lumbar puncture is often clear but usually contains 50 to 200 cells, mostly mononuclears, with a positive globulin reaction. There may be film formation. Occasionally turbid fluid is obtained, and there may be found a small number of meningococci, both intra- and extracellular. The usual duration of the disease is from two to five months; death may occur from convulsions, or from some intercurrent disease, such as pneumonia, but most frequently from malnutrition. The prognosis is bad except when the cause is syphilis, when great improvement may take place.

**Diagnosis.**—The disease is to be distinguished from tuberculous meningitis, and from the opisthotonos of reflex origin which is occasionally seen in infants suffering from malnutrition. It differs from tuberculous meningitis in its more protracted course, in the absence of fever, paralysis, and of any evidence of tuberculous infection as well as in the greater prominence of the opisthotonos and hydrocephalus.

**Treatment.**—If meningococci are found, antimeningococcus serum should be used. It will usually destroy the organisms, although it cannot affect the pathological changes that have taken place as the result of their long activity. If there is any reason to suspect syphilis, antiluetic treatment should be administered. Operations for the relief of the hydrocephalus have, up to the present time, met with little measure of success.

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## CHAPTER CXXXV

### ACUTE MENINGITIS DUE TO OTHER PYOGENIC ORGANISMS

Any of the common pyogenic organisms may produce acute meningitis. In some instances this develops as a secondary process, but at other times the meningitis is apparently primary. Cases of meningitis due to the typhoid bacillus, the gonococcus and the colon bacillus have all been reported in children, but are so rare as only to deserve mention. Meningitis due to a pneumococcus, the influenza bacillus, a staphylococcus or a streptococcus is, however, of sufficient importance to warrant a separate description.

**Pneumococcus Meningitis.**—This is the most important variety included in this group and the one most frequently met with in young children. In our hospital patients under three years of age, about 10 per cent of the cases of acute meningitis were of this form. Nearly all had pulmonary symptoms of greater or less severity, usually a definite pneumonia with consolidation; several had also empyema. Less frequently, pneumococcus pericarditis and peritonitis have been present. Meningitis may also result from pneumococcus otitis and mastoid disease. Occasionally pneumococcus meningitis is apparently a primary inflammation, but in most cases it results from pneumococcus septicemia. In all of our cases the pneumococcus has been recovered from the heart's blood at autopsy; it has usually been found in blood cultures made during life. This form of meningitis occurs in infants more frequently than in older children, and, in our experience, usually in very young infants; over half of the cases seen were in patients under six months old. While the disease usually develops at the height of an attack of pneumonia, it may precede the pulmonary symptoms or it may develop during convalescence. We once saw it as late as the fourth week.

In a general way the anatomical changes resemble those described in acute meningococcus meningitis. As a rule, however, the lesions are limited to the brain; if the cord is involved, it is only to a slight degree.

Pneumococcus meningitis is characterized by a more abundant exudation of fibrin and pus than is usually seen in any other variety of meningitis. The lesion may affect the entire brain, but it is especially marked at the convexity and over the anterior lobes. Sometimes it is limited to these regions, the meninges of the base escaping. The exudate may be so abundant as to conceal the convolutions completely over a large part of the surface of the brain. There is usually less distention of the ventricles than in meningococcus meningitis.

In cases apparently primary, or when meningitis occurs early in the course of a general pneumococcus infection, the symptoms are usually indistinguishable from those of ordinary cases of meningococcus meningitis. It is generally not until lumbar puncture is made that the variety of meningitis is suspected. When meningitis occurs as a secondary inflammation it is often latent, and not



infrequently is found at autopsy when not suspected during life. Usually, however, the meningeal complication is indicated by the abrupt development, in the course of an attack of pneumonia, of vomiting or convulsions, followed by active delirium or stupor. Because the lesion is principally, sometimes only, at the convexity, many of the symptoms belonging to meningitis with basal lesions are absent. There is rarely cervical opisthotonos; the fontanel may not be bulging; pulse and respiration may not be disturbed, in fact, there are no cranial nerve symptoms and the symptoms due to spinal involvement—hyperesthesia, rigidity, Kernig's sign, etc.—may be wanting or only slightly marked.

The course of pneumococcus meningitis is generally short and acute, death taking place within three or four days from the first symptoms. We have several times seen a prolonged type of the disease lasting many weeks; one case ended fatally near the end of the third month, a localized area of meningitis being found at the convexity at autopsy; another patient recovered from the acute symptoms, but remained partially paralyzed and mentally defective.

The diagnosis of pneumococcus meningitis can be made certain only by examining the cerebrospinal fluid. The fluid in gross appearance does not differ from that seen in cases due to the meningococcus. The cells present are chiefly polymorphonuclears. Pneumococci are very abundant and are easily found in smears and readily grown in cultures. We have occasionally seen a turbid cerebrospinal fluid with only a slight increase in cells. The turbidity was due to pneumococci in enormous numbers. The existence of pneumococcus meningitis is not always shown by lumbar puncture. An entirely normal spinal fluid may be obtained, while cistern or ventricular puncture will reveal a typical purulent fluid.

**Influenza Meningitis.**—This form of meningitis is not very rare. We see four or five cases each year. Of those which have come under our own observation, nearly all have been infants and all but two have ended fatally. In our experience, influenza meningitis has usually been secondary to other infections, usually those of the rhinopharynx or bronchi. One patient, an infant of eight months, was admitted to the hospital with an acute abscess of the elbow joint. Two days later symptoms of meningitis developed, and death occurred in three days. The autopsy showed an extensive purulent meningitis. Cultures of the influenza bacillus were obtained from the pus of the elbow, the fluid drawn by lumbar puncture, the meningeal exudate, the lungs, and the heart's blood.

The lesions of influenza meningitis differ in no particular essential from those described in the pneumococcus variety. In the cases that have come under our observation in which examinations were made, the influenza bacillus has usually been obtained from the heart's blood as well as from the cerebrospinal fluid.

Clinically, influenza meningitis usually runs a short, very acute course. Exceptionally it may be prolonged for four or five weeks or more. There are no features by which it can be distinguished from the pneumococcus or meningococcus forms, except the findings of lumbar puncture. In gross appearance the fluid does not differ from that seen in the other forms. There is usually marked turbidity; the cells are abundant and of the polymorphonuclear variety. The organisms are generally not numerous in the smears, in marked contrast to the other forms of meningitis. They are readily grown upon blood agar, but not



upon ordinary media. Rivers has shown that most of the strains of influenza bacilli that cause meningitis produce indol. If, therefore, no organisms can be demonstrated in the smears from a turbid cerebrospinal fluid, a test for indol with Ehrlich's reagent should be performed. A positive test is pathognomonic. Serum therapy in the past has met with little success, but some progress is being reported along this line.

**Staphylococcus and Streptococcus Meningitis.**—Meningeal inflammations set up by streptococci or staphylococci are not very common in young children. They are almost always secondary. In the newly born this form of meningitis is seen in general pyemia, usually from umbilical infection; it also follows infection of a spina bifida. In older children it follows injuries to the head, erysipelas of the scalp, operations upon the brain, and otitis media with mastoiditis or sinus thrombosis. Such a complication of otitis in infancy is, however, extremely rare. The lesions consist in a widespread general inflammation of the pia with an abundant exudate of pus, but with less fibrin than in the two varieties previously described.

The symptoms of septic meningitis are not distinctive. The course is usually a rapidly progressive one, and it terminates almost invariably in death. Recoveries have, however, been reported in all types of meningitis. The fluid drawn by lumbar puncture in most cases is markedly turbid, and shows great numbers of pus cells. The organisms are present in large numbers and are readily recognized both in smears and by cultures upon ordinary media.

The differential diagnosis of the different forms of pyogenic meningitis from each other, and from other diseases with cerebral symptoms, is made with certainty only by examination of the cerebrospinal fluid, which should be done in all cases of doubt. The appearance of the fluid is essentially the same whether the inflammation is due to the meningococcus, the pneumococcus, the influenza bacillus, or to the staphylococcus or streptococcus. The symptoms of meningitis in general, described in the chapter on Meningococcus Meningitis, are present in most of the cases. The differentiation from abscess is discussed under the latter condition.

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## CHAPTER CXXXVI

### TUBERCULOSIS

#### GENERAL CONSIDERATIONS

Tuberculosis is a specific infection caused by the tubercle bacillus of Koch. It may involve almost any part of the body. The process may remain localized or become generalized; it may be either active or latent. To the latent form the term "tubercle" is often applied as contrasted with "tuberculous disease," in which the process is active. The borderline between the two is often difficult to define. Tuberculosis is exceedingly common in all parts of the civilized world. Its importance in childhood in urban communities is shown by the mortality statistics. In Baltimore it causes approximately 2 per cent of deaths during the first year and from 3 to 5 per cent of deaths under six years of age.

**The Bacillus.**—The properties of this organism are responsible for the characteristic features of the disease. Its slow rate of growth and reproduction determine in large measure the chronic course. The waxy lipoid substances of the capsule are responsible for its peculiar staining properties, and determine also the character of the tissue response in the absence of allergy (anergic states). Under these conditions the response is little more than that caused by various inert foreign bodies. The proteins of the bacillus (tuberculins) are to a greater or lesser extent irritating substances. They give rise to the phenomena of hypersensitiveness, and under these conditions their toxicity may become enormously increased. The acute manifestations of tuberculosis depend largely upon hypersensitiveness to tuberculo-protein, as do most of the specific diagnostic reactions. It was formerly believed that only the proteins of the bacillus were concerned in specific antibody reactions, but recent work has shown that both lipoid and carbohydrate substances in the bacillus may play a rôle.

**Reactions of the Body to the Tubercle Bacillus.**—A number of typical reactions are met with. (a) The *proliferative reaction* resulting in the formation of compact masses of epithelioid cells or of tubercles with giant cells, epithelioid cells and lymphocytes. This is the usual response in an individual infected for the first time, who is not allergic. It may be met with in allergic individuals if the infecting dose is small.

(b) *Exudative Reaction.*—This is a typical inflammation with exudation of serum and leukocytes. It is met when there is hypersensitiveness to tuberculin (individuals rendered allergic by previous infection), or when large numbers of bacilli are present.

(c) *Necrosis (Caseation).*—This may result when large numbers of bacilli are present at one site in a nonallergic body; a smaller number of organisms suffices to kill tissue when hypersensitiveness is present. If the necrotic area per-



forates a hollow viscus through which its contents may be discharged, a cavity results.

These phenomena may occur independently, together, and associated with:

(*d*) *Various Types of Repair*.—It is possible for tubercles and for tuberculous inflammations to resolve completely. More often there remains fibrosis of greater or lesser extent. Where there has been necrosis of tissue calcification may occur.

**Resistance**.—The course of any particular infection will depend upon a number of factors: the number and virulence of the infecting organisms, the state of hypersensitiveness of the individual's tissues, and the resistance of the tissues to the survival and multiplication of the bacilli. The nature of this resistance is still a matter of uncertainty. Explanations that have been offered are: (*a*) that resistance is anatomical: "the individual is as resistant as the fibrous shell surrounding his tubercle"; (*b*) that resistance is due to allergy. While it seems likely that both of these factors may at times play a protective part, it is difficult to believe that resistance is primarily due to anatomical factors or to allergy. Under conditions of lowered resistance tuberculosis advances not only through dense layers of fibrous tissue, but through bone itself without difficulty. Allergy is often extreme under conditions of rapidly spreading infection in which resistance appears to be negligible; moreover, there can be no doubt that the destructive effects of allergy are often disastrous rather than protective. For these reasons the belief has gained ground that (*c*) resistance is due primarily neither to fibrosis nor to allergy but to a different type of immune reaction which inhibits the free growth and spread of bacilli. Resistance may persist after allergy has disappeared.

Whatever the nature of resistance may be, one can point to certain conditions which appear to exercise an unfavorable influence upon it, and which may be regarded as predisposing factors to tuberculous disease. Poor hygienic conditions in general and lack of sunlight in particular may do this. The peculiar susceptibility of Negroes and the dark-skinned Mediterranean races has been attributed to pigmentation of the skin interfering with the passage of the sun's rays. A familial susceptibility to the disease is no longer believed to play a dominant rôle, the high incidence in certain families being mainly the result of contact. It is probable that a number of acute infections may cause a flare-up of a tuberculous process; this is particularly true of measles and whooping cough. Such infections unquestionably affect the state of allergy to tuberculoprotein, but it is not clear that this is the mechanism by which resistance is altered.

Little is known regarding the importance of *local* factors in resistance to tuberculosis. Animal experiments have shown that infection occurs with greater ease in the presence of a nontuberculous inflammation. When pulmonary lesions are present it is customary to avoid irritants, such as ether anesthesia, which might permit a local extension of the process.

**Incidence of Tuberculous Infection**.—This varies considerably in different countries; there is also a marked difference between urban and rural communities, infection being more frequent in cities owing to the greater opportunities for exposure. An impression of the frequency of tuberculous infection at different ages may be obtained from the accompanying chart.



The actual incidence of tuberculous infection is, however, greater than these figures—which are based on routine intradermal tuberculin reactions—would indicate. A certain number of infected individuals may at one time or another show such a low degree of allergy that they will react negatively to the routine test. It is clear that in cities tuberculosis is usually acquired during childhood, and that few escape it before reaching adult life.

**Source of Infection.**—Congenital tuberculosis, in which the infection is acquired through the placenta, is an exceedingly rare event. The child may be still-

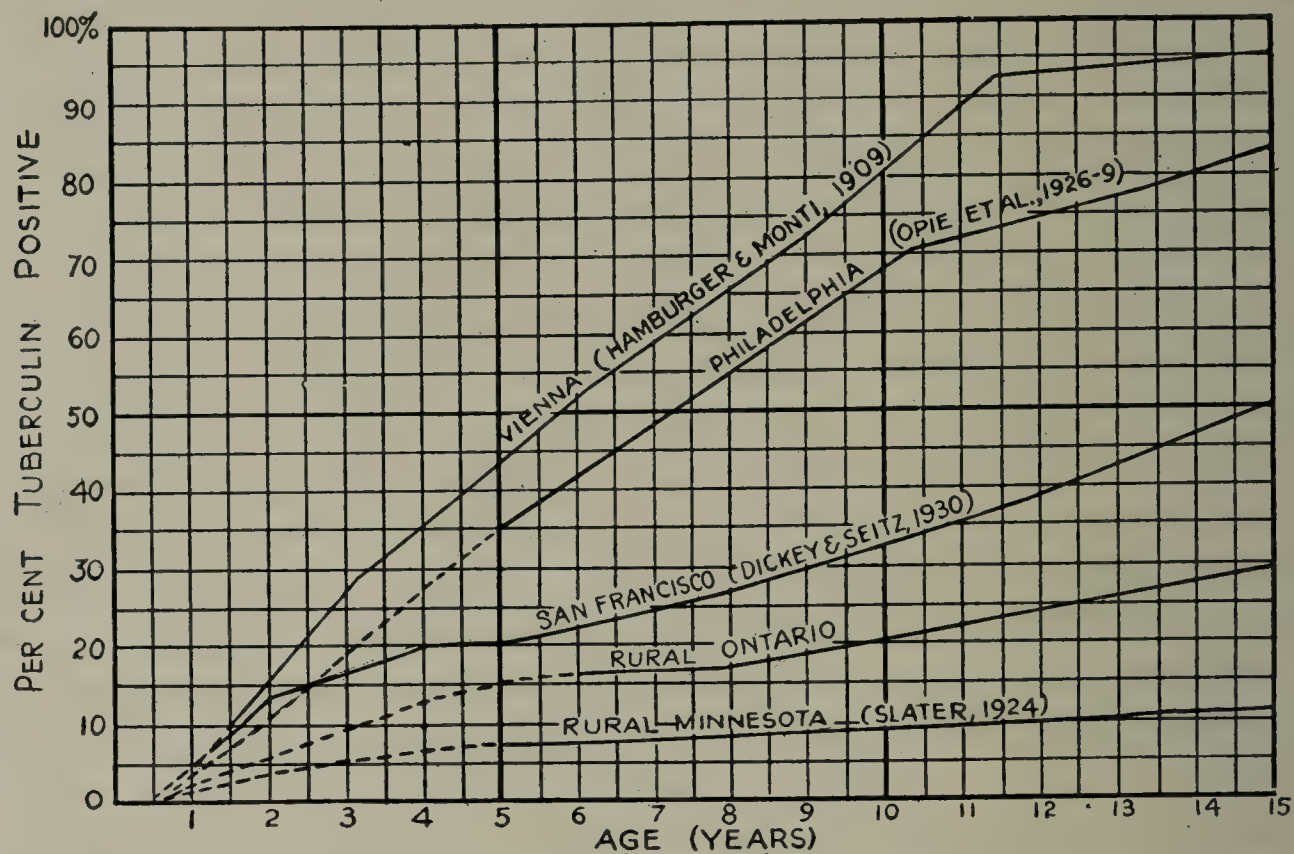


FIG. 163.—PERCENTAGE OF CHILDREN OF DIFFERENT AGES WHO REACT POSITIVELY TO INTRACUTANEOUS TUBERCULIN.

The differences observed in the incidence of positive reactions in Vienna, Philadelphia and San Francisco may be in part explained by the source of material. The Vienna studies were made on public hospital and dispensary patients; the Philadelphia statistics were from children attending public school, and the San Francisco statistics, although they were obtained from a dispensary, included many part-pay patients.

born or may survive for several weeks. Widespread tuberculosis is found at autopsy. In such cases the placenta shows evidence of tuberculosis, and lesions may be found in the umbilical cord.

The most frequent source of infection is contact or close association with an individual suffering from the disease, usually a parent or some member of the household—a nurse, caretaker, servant or frequent visitor. Droplets of sputum, sprayed by coughing, sneezing, or in speech, may be inhaled directly, or dried sputum containing bacilli may become a part of the dust of the room and be inhaled or introduced into the mouths of children by hands, toys or other objects. Very commonly the bacilli are conveyed by kissing. Instances are recorded in which the disease has been conveyed by a human bite; we are familiar with two cases in which it resulted from ritual circumcision.<sup>1</sup>

<sup>1</sup> A striking instance of direct infection is reported by Reich. In a town of 1300 inhabitants, the obstetric practice was divided between two midwives. Within fourteen months, no less than 10 infants delivered by one of these women died of tuberculous meningitis. In none of these families was there a history of tuberculosis. This midwife was found to have pulmonary tuberculosis, and died from that disease. It was her custom to



The individual responsible for transmission may be known to be suffering from active tuberculosis; at other times the disease is supposed to have been cured. Sometimes the appearance of tuberculosis in a child is the first warning of illness in an adult member of the household. As Park has expressed it: "There is more than one way of telling whether or not an adult has an open tuberculous lesion; one can find the bacilli in his sputum, or one can find the infection in his baby." It is possible to obtain a history of exposure in the majority of instances, but not in all. Infection may take place from beds, rooms, sleeping cars or any apartment previously occupied by a tuberculous patient; it may arise from dishes, spoons or glasses at public places; the dust of the street may be the source.

Infection through milk is by no means infrequent. In certain communities where raw milk is sold and where the destruction of tuberculous cattle is not compulsory, tubercle bacilli of the bovine type can commonly be demonstrated in the milk. They are usually present in small numbers and it is likely that they often pass through the intestinal tract without producing infection.

The interval between exposure and the development of symptoms (when active tuberculosis follows) is variable. In a series of cases in which this point was studied at the Babies' Hospital in New York, it was found to be from four weeks onward.

**Portal of Entry.**—As pointed out above, infection through the placenta or through the skin are both exceedingly rare. The two common paths of infection are inhalation and ingestion. When the source is human, infection may occur by either route, although inhalation appears to be considerably more frequent. Bovine infections, coming almost invariably from infected milk, are acquired through the alimentary tract. Infections acquired by ingestion may occur by way of the tonsils or the intestines. Table LIII gives the type of organism obtained by Park and Krumwiede (1912) in 543 cases of tuberculosis in children. These figures indicate that bovine infections, although they may become generalized, are less likely to do so than are infections with the human bacillus.

**Peculiarities of Tuberculosis in Childhood.**—*Primary Tuberculous Infection.*—Tuberculosis in childhood is usually a primary infection, whereas adult tuberculosis is almost always secondary—a disease process in an individual previously infected and possessing some degree of acquired resistance. The term "childhood type of tuberculosis" has been used to describe the primary tuberculous infection; since the great majority of persons acquire their primary infection before reaching adult life, this type of tuberculosis is rarely seen among adults.

Tuberculosis of the "adult type"—occurring in an individual already infected—is sometimes seen in childhood; it is rare in young infants, but becomes increasingly frequent in older children, particularly after the age of puberty. The "adult type" of tuberculosis when it occurs in children is in no way different from that seen in adults. A description of the peculiarities of tuberculosis in childhood therefore resolves itself into a discussion of the characteristics of primary tuberculous infections.

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remove the mucus from the mouth of the newly born infants by direct mouth-to-mouth aspiration, and then to establish respiration by blowing into the nose. In the practice of the other midwife who was healthy no cases of tuberculosis occurred, although she treated the newly born infants in the same fashion,



TUBERCULOSIS

TABLE LIII

TUBERCULOUS LESIONS AND TYPE OF ORGANISM FOUND IN 543 CASES  
(PARK AND KRUMWIEDE)

Lesions	Children under 5 Years		Children over 5 Years	
	Human	Bovine	Human	Bovine
Pulmonary .....	35	1	14	0
Adenitis, axillary and inguinal.....	2	0	4	0
Adenitis, cervical .....	15	24	36	22
Abdominal .....	10	14	8	9
Generalized .....	74	7	5	1
Generalized, alimentary origin.....	17	15	3	4
Generalized and meningeal (alimen- tary origin) .....	5	10	1	0
Generalized and meningeal.....	76	1	10	0
Meningeal .....	28	4	3	0
Bones and joints *.....	27	0	41	3
Skin .....	2	0	4	6
Genito-urinary .....	0	0	2	0

\* Frazer states that "of a series of cases of bone and joint tuberculosis studied in Edinburgh 62 per cent were bovine in their origin." Apparently the incidence of bovine infection varies considerably in different countries. The inference is that the milk supply of Scotland is more likely to be infected than that of some other places.

When tubercle bacilli first gain a foothold in the body they set up a characteristic lesion consisting of (1) the primary tuberculous focus at the site of first penetration, (2) a tuberculous lymphangitis leading from this to the regional lymph nodes and (3) lymphadenitis of the regional lymph nodes with extensive inflammation and a tendency to caseation. This triad is known as the *primary complex*, and we owe especially to Parrot, Ranke and Ghon the recognition of its significance. In the great majority of cases there is but a single primary complex; occasionally there are multiple foci. The location of the primary complex is practically always in the lung, as is borne out by the accompanying table from Ghon and Kudlich. Even when the organisms are not inhaled they usually reach the lung with great ease by the circulation.

TABLE LIV

LOCATION OF PRIMARY FOCUS (FROM GHON AND KUDLICH)

	Number	Per Cent
Lung .....	2,028	95.93
Intestine .....	24	1.14
Skin .....	3	0.14
Nose .....	2	0.09
Tonsil .....	2	0.09
Middle ear .....	2	0.09
Parotid .....	1	0.05
Conjunctiva .....	1	0.05
Undetermined .....	51	2.41
TOTAL .....	2,114	100.00



It is characteristic of primary complexes that the process may be far more conspicuous in the regional nodes than at the original site of lodgment. The original focus may be negligible in size or may heal promptly, whereas the lymph nodes are the seat of extensive caseation. In some instances organisms apparently pass through the parenchyma leaving no trace and the only evidence of infection is in the regional lymph nodes.

The process may, however, be quite as conspicuous at the site of implantation as in the regional nodes. In either location it is characterized by acute inflammatory changes with a tendency to necrosis. This may cause local extension or generalized dissemination by erosion of blood vessels.

The characteristics of primary infections, then, are: (*a*) extensive involvement of the regional lymph nodes, (*b*) rapidly progressing caseous lesions, and (*c*) a tendency for the process to become generalized. The explanation of these peculiarities lies in the late development of allergy and resistance, some weeks after the primary inoculation. In the newly infected individual the bacilli multiply rapidly and there is extension first to the regional lymph nodes and perhaps throughout the body. As resistance develops the ability of the organisms to propagate and spread is impaired. This may occur in time to prevent dissemination throughout the body, but not before heavy infection with proliferation of organisms in the regional lymph nodes has taken place. As tissue resistance is acquired, a number of the organisms die and from them are liberated large quantities of tuberculo-protein. By this time, however, a high degree of hypersensitiveness has developed and there results a violent inflammatory reaction with a marked tendency to necrosis.<sup>2</sup> Fibrosis does not occur to any great extent, for the lesion spreads so rapidly that there is little opportunity for repair.

The adult type of tuberculosis with a slowly progressive lesion, tending to be encapsulated by fibrous tissue, is seldom seen in young children. It may be attributed to reinfection or to slow progress of a primary infection in an individual with some acquired resistance. In resistant individuals the bacilli do not multiply rapidly; the progress of the lesions is slow and there is ample opportunity for fibrosis and repair. Only occasionally do organisms escape to the lymph nodes, and here again they meet tissue resistance; hence there is little tendency for them to proliferate and for a generalized infection to develop.

**Incidence of Tuberculous Disease.**—The statistics given in Table LV, on the following page, which were compiled from the Harriet Lane Home, indicate the prevalence of active tuberculosis in a typical dispensary and hospital population.

Reliable data showing the relation between tuberculous infection and tuberculous disease at different ages are difficult to obtain. One difficulty lies in drawing a sharp line between what is classed as active and what as latent tuberculosis. It is certain, however, that the younger the infected subject the greater is the likelihood of activity.

**Resistance of Children to Tuberculosis.**—It is obvious that the older the child, the more likely is resistance to tuberculosis to be found, since the probability of his having had a primary infection conferring acquired resistance increases steadily

<sup>2</sup> Necrosis does not invariably follow the extensive inflammations seen at this period of extreme hypersensitiveness. Not infrequently there are encountered large areas of tuberculous inflammation which during the course of months tend to disappear almost completely (*cf.* epituberculosis).



TABLE LV  
PREVALENCE OF ACTIVE TUBERCULOSIS

	Children with Active Tuberculosis under 6 Years of Age		
	0-1 Year	1-2 Years	2-6 Years
Skin and suppurative glands.....	5	6	27
Bones and joints.....	4	4	22
Abdominal .....	2	2	7
Pulmonary .....	50	62	79
Terminal (miliary and nervous system) .....	55	46	41
All forms .....	116	120	176
Total children examined * .....	7,106	2,242	4,310
Per cent with active tuberculosis...	1.6	5.3	4.1

\* These cases were in no way selected, but represented consecutive admissions to the dispensary and wards from 1923 to 1928.

with age. The question arises, however, as to whether the resistance of a previously uninfected individual is in any way affected by age. Accurate data are not available which might settle this point. Clinical observations suggest strongly that primary infection in young infants is more likely to have serious consequences than primary infection at—let us say—four or five years of age. We are inclined to attribute this to a difference in the quantity and frequency of the infecting dose. The infant, as a rule, is infected from a parent or nurse with whom he is in close contact and from whom he is likely to receive large doses of bacilli at frequent intervals. While the older child may be similarly infected, there is a greater probability that he will receive his primary infection from dust or a variety of other sources where occasional isolated tubercle bacilli may occur. Consequently the primary infection is more likely to be well handled. It is possible, however, that age itself has some influence. There is some evidence from work with experimental animals which suggests that, following a primary infection, resistance is more slowly acquired in young animals than in old.

**Lesions of Childhood.**—In Table LVI are given the lesions found in 433 autopsies of which we have notes. Most of these children were under three years old. For comparison are given statistics from the Pendlebury Hospital, Manchester, England, on children over three years of age.

These statistics illustrate some of the differences in the lesions found in young infants as contrasted with older children. Alimentary infection is probably slightly less common in infants since breast-fed infants are not infected in this way. Pleural lesions occur less frequently in infancy but lesions in the bronchial lymph nodes are more constantly found. Tuberculosis of the skin, the bones and the peritoneum become more frequent with increasing age.

SPECIFIC DIAGNOSTIC PROCEDURES

The recognition of local lesions of tuberculosis, whether by clinical or laboratory methods, will be discussed in connection with the clinical manifestations. In the



TABLE LVI  
FREQUENCY OF DIFFERENT VISCERAL LESIONS OF TUBERCULOSIS

Organs	Babies' Hospital 433 Autopsies, Chiefly under Three Years, Per Cent	Pendlebury Hospital 131 Autopsies, Chiefly over Three Years, Per Cent
Lungs .....	92.1	93.0
Bronchial lymph nodes.....	87.3	70.0
Spleen .....	74.9	58.0
Liver .....	69.8	65.0
Mesenteric lymph nodes .....	53.3	50.0
Intestines .....	43.1	50.0
Pleura .....	36.5	76.0
Brain and meninges.....	35.5	46.0
Kidneys .....	30.6	41.0
Peritoneum .....	8.6	28.0
Heart and pericardium .....	4.3	3.0
Stomach .....	2.7	0.8
Thymus .....	1.9	0
Adrenals .....	1.5	1.6
Pancreas .....	1.5	0

present section there will be taken up the specific diagnostic reactions which indicate the presence of a tuberculous focus somewhere in the body.

**Tuberculin Skin Tests.**—Either one of two methods may be used: the intracutaneous (Mantoux) or the cutaneous (Pirquet) method.<sup>3</sup> The Pirquet test is made with undiluted tuberculin, which keeps indefinitely; it is therefore the one generally employed for home and office practice and for occasional use. The intracutaneous Mantoux test is more sensitive and more reliable, and no more painful; when frequent tests are to be made, as in a hospital, it possesses many advantages; the dilutions of tuberculin must be frequently and accurately prepared.

With the intracutaneous test a known amount of tuberculin (O.T.) diluted in saline solution is injected into the substance of the skin. The volume injected is 0.1 c.c. A control test with a similar dilution of sterile glycerin broth may be carried out at the same time. The control injection should be located more distally. The test is most conveniently applied on the flexor surface of the forearm. The skin is carefully washed with alcohol and allowed to dry. The needle is inserted superficially and the injection made within and not beneath the skin. When properly injected a pale elevation is produced. A different syringe and needle should be used for the control injection. The dose usually given is 0.01 milligram (0.1 c.c. of 1:10,000 dilution) or 0.1 milligram (0.1 c.c. of 1:1,000 dilution). It is our practice to employ 0.001 milligram or less in cases where extreme hypersensitiveness is suspected, particularly when eye lesions (phlyctenular conjunctivitis) are present. In case a negative reaction is obtained at the end of forty-eight hours the dose may

<sup>2</sup> The percutaneous (Moro) test, in which an ointment containing tuberculin is rubbed into the skin, has been used to some extent in Europe. It is difficult, however, to control the amount of tuberculin so applied. The test is less accurate than either the Mantoux or the Pirquet method.



be increased. A few tuberculous individuals will require 1 milligram (0.1 c.c. of 1:100 dilution) or even 5 milligrams before a positive reaction is obtained.

With the Pirquet test a small drop of pure tuberculin (O.T.) is placed upon the skin and a linear scratch 3 to 4 millimeters in length is made through this with a sterile needle. A control scarification is made 2 or 3 inches distal to this. The child should be watched, and, if very young, the arm should be held until the skin is quite dry. A sterile dressing may then be applied.

The reaction is similar with the two tests. There is an area of redness and induration varying from a few millimeters to 3 or 4 centimeters which appears at the site of injection. It usually begins within the first twenty-four hours, reaching its maximum at about forty-eight hours, at which time the test should be read. Rarely the reaction is delayed and appears only after seventy-two hours. When the reaction is severe, necrosis may occur at the site; there may be a local lymphangitis and enlargement of the regional nodes.

For routine clinical work tuberculins from human and bovine strains are interchangeable and give essentially the same reactions.

**Significance of the Tuberculin Reaction.**—A positive tuberculin reaction indicates the *presence* of allergy to tuberculin. It is an excellent indicator of tuberculous infection,<sup>4</sup> for, although allergy fluctuates under a variety of conditions, it seldom if ever disappears entirely. The test gives some further information as to the *degree* of activity. In general, a high degree of allergy is associated with an active process, and conversely, but there are many exceptions to this. A number of factors, quite apart from the tuberculous process, may cause allergy to wax or to wane; hence one must be extremely cautious in drawing conclusions as to the activity of the process from the degree of allergy alone. Certain infections, notably measles, may cause allergy to disappear almost completely, so much so that it cannot be detected by the Pirquet test. In moribund patients allergy tends to disappear. It should be emphasized that the allergic reaction gives no information whatever in regard to the *extent* of the tuberculous process; a focus of microscopic size may produce hypersensitiveness of the skin quite as marked as the most widespread tuberculosis.

In the interpretation of tuberculin reactions greater significance attaches to a negative than to a positive test. A negative reaction, particularly if the dose has been carried up to 1.0 or 5.0 milligrams, is sufficient to rule out tuberculosis. The exceptions to this are rare—moribund patients, certain depressing infections and freshly acquired tuberculosis in the pre-allergic stage. A positive reaction is significant only in infants and young children. The younger the child the greater the probability that it is associated with an active process. It was formerly believed that an infant under one year infected with tuberculosis was doomed. This view is unquestionably erroneous; although a positive reaction under one year must be regarded as of serious import, it is often encountered in infants who handle their infection well and fail to develop progressive tuberculosis.

The use of tuberculin subcutaneously or intramuscularly has been advocated. It possesses the advantage that with appropriate doses a *constitutional* and a *focal*

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<sup>4</sup> Allergy can be produced by inoculation with dead organisms. It has not, however, been produced by tuberculin alone.



reaction as well as a *local* one are obtained. We are inclined to believe that this procedure is a dangerous one and not to be recommended. The same may be said of the ophthalmotuberculin (Calmette) reaction.

**Examination of the Stomach Contents for Tubercle Bacilli.**—Young patients are likely to have open pulmonary lesions even when cough and expectoration are absent. The organisms given off from lesions in the lung are swept toward the larynx either by coughing or by ciliary action and are swallowed without being brought forward into the mouth. Poulsen recovered tubercle bacilli from the stomach washings of infants under one year of age showing a positive tuberculin reaction in all instances studied. After the first year the percentage of recoveries of the organism diminishes, but the method is a valuable one throughout childhood.

The patient is examined in a fasting condition. A stomach tube is passed in the usual way and the stomach washed out with 100 c.c. of water or 2 per cent sodium bicarbonate solution. The washings may be centrifuged directly, or treated with 10 per cent of their volume of 40 per cent sodium hydroxide and warmed in an incubator for solution of mucus before centrifuging. Prolonged centrifuging at high speed throws down the organisms, which may then be demonstrated in a stained smear or, in doubtful cases, cultured on Petroff's media or inoculated into a guinea-pig.

Other specific tests for tuberculosis are not to be compared in value to the tuberculin reaction. Complement fixation has been used with some success by Petroff and others; in the hands of most workers it has proved unsatisfactory.

**Blood Picture in Tuberculosis.**—Attention has recently been drawn to this, particularly by Sabin and her coworkers. It is claimed that the ratio of monocytes to lymphocytes rises in healing tuberculosis and is depressed when the process is advancing; epithelioid cells may be demonstrable in the blood during the stage of activity. The cells in question are identified by supravital staining methods. The test has a very limited practical value.

#### PROPHYLAXIS OF TUBERCULOSIS

The prevention of tuberculous infection is a matter of avoiding all possible exposure to persons, foods and articles which might serve as sources of tubercle bacilli. The degree to which such precautions are carried out will vary with the age of the child and whether or not he has acquired a primary infection. Known sources of tuberculosis should be avoided at all ages; with infants one should go further and spare no effort to avoid potential sources as well.

The human sources are by far the most important. Under no circumstances should an infant be allowed to remain in the same household with a tuberculous individual; separation from a tuberculous mother in particular should be insisted upon. No nurse or servant should be employed who has or has had active tuberculosis. Persons whose tuberculosis has been confined to the bones or cervical lymph nodes, or to a pleurisy with effusion are no doubt less of a menace than those who have open pulmonary lesions. Experience has shown, however, that individuals with supposedly healed tuberculosis may convey the disease. With older children such extreme precautions may gradually be relaxed, particularly if a child has already acquired a primary infection. If a tuberculous member of the family must reside



in the house the most rigid precautions should be insisted upon. Raw milk should not be used for infants and young children unless it is known to come from cows which are regularly tested with tuberculin.

Recently the attempt has been made to protect against tuberculosis by inoculation with bacilli of low virulence, notably the Calmette-Guérin bacillus (B.C.G.). It is claimed that this organism produces only a local lesion and that it leads to the development of acquired resistance, so that subsequent infections with virulent organisms are well handled. The latter claim is well substantiated; in regard to the former, however, there appears to be some doubt.

Instances have been reported in which B.C.G. has apparently led to the development of generalized tuberculosis, so that this method<sup>5</sup> cannot be said to be without risk. Inoculation with B.C.G. is not a certain protection against tuberculous infection, but it probably does increase resistance. It should not be employed as a general measure. The only possible justification for its use is for the protection of babies destined to be exposed to individuals with active tuberculosis. It is probably a dangerous procedure to give living tubercle bacilli to human beings—one risk being the chance of admixture with virulent bacilli, such as accidentally occurred with most disastrous results at Lübeck. Vaccination with dead organisms, first advocated by Langer and more recently by Petroff, appears to be a safer and perhaps equally effective method of producing resistance.

#### TREATMENT

Local therapeutic measures will be discussed in connection with the clinical manifestations. The following section will be devoted to general measures in the treatment of tuberculosis.

**Management of the Latent Infection.**—It is difficult to generalize here. On the one hand we may have to deal with an older child who exhibits by x-ray one or two calcified glands in the hilum or in the abdomen and who reacts, but with no great intensity, to tuberculin, and who obviously has latent tuberculosis of no great extent. Such an individual can scarcely be considered abnormal. Although care should be taken to see that his nutrition is maintained, that his food is proper and that overexertion is avoided, he should occasion no particular concern. On the other hand, we may have a child who, though afebrile and symptom-free, shows more or less extensive x-ray shadows at the hilum of the lung and who may exhibit a high degree of sensitiveness to tuberculin. Although clinically latent, such a process cannot be considered inactive nor should it be lightly regarded. Since the infection is probably a recent one, a thorough study of the home environment should be made; this may reveal a member of the household suffering from unsuspected active tuberculosis. Every effort should be made to prevent further infection. Such a child needs careful watching; his temperature should be taken regularly, so that in

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<sup>5</sup> Calmette advises giving by mouth, within the first ten days of life, 10 milligrams of B.C.G. culture suspended in broth, every two days until three doses have been given. The patient should be isolated from possible contacts until allergy has developed, which may require three to eighteen weeks. In a number of cases the organisms pass through the alimentary tract without invading the host. Greater certainty of inoculation is afforded by injecting the organisms directly. After subcutaneous injection, caseous adenitis of the regional lymph nodes often occurs with softening and, in many cases, unsightly scarring. Intradermal injection of 1 milligram of B.C.G. has been used by Wallgren and others with more satisfactory cosmetic results and an equally high production of allergy.



case he develops fever he may be put to bed. No strenuous exercise should be permitted; great care should be taken to see that he receives a nutritious diet, fresh air, and a proper amount of rest and sleep. Heliotherapy may be indicated, a change of climate or removal to a preventorium or sanatorium may be advisable. Great care should be taken to prevent infections, particularly measles and whooping cough. If, for one reason or another, he requires a general anesthetic, ether should be avoided. A close observation should be maintained and the process followed carefully by x-ray until such time as it may be considered to be inactive—a period of a year or more, at the least. Between these two types of clinically latent tuberculosis are seen all sorts of variations; each case must be treated on its own merits.

**Management of Active Tuberculosis.**—When fever or symptoms of disease are present, rest in bed is imperative. Aside from this particular, the treatment is identical with that just outlined. The infant or young child with active tuberculosis is less of a menace than an adult with a similar condition. Sputum is usually swallowed and there may be little cough. Nevertheless, if other children and infants are about, rigid isolation should be enforced. The increase in sanatorium facilities for young children is making it possible to treat these cases more successfully, as well as to protect other children.

**Heliotherapy.**—This is probably the most valuable agent we possess in the treatment of tuberculosis. Irradiation with mercury-vapor quartz arcs, carbon arcs and other types of artificial actinotherapy appears to be inferior to sunlight. Heliotherapy is most effective in surgical forms of tuberculosis, those involving the bones and joints, the superficial lymph nodes, the abdomen and the skin. Experience with adults has shown that in the presence of active pulmonary disease the treatment must be used with caution. Exposure should always be commenced gradually, beginning with a few minutes daily and increasing until the child may be exposed the greater part of the day.

**Diet.**—Tuberculous children should receive adequate amounts of all the vitamins, particularly vitamins A and C. Experimental studies have shown that scurvy decreases resistance to tuberculosis, and there are observations on adults indicating that liberal additions of vitamin C in the form of orange juice to ordinary diets exercise a favorable influence on the course of the disease. The intake of vitamin D should not be less than one would give to a growing organism for prevention of rickets. Whether larger doses of vitamin D have a favorable effect on resistance to tuberculosis by accelerating calcification of healing lesions is highly doubtful.

Calcium and phosphate should be available from dietetic sources for the promotion of healing. The mineral content of a quart of milk a day is ample, and need not be supplemented.

Numerous attempts have been carried out, particularly on the Continent, to favor healing by special dietetic programs. In the Gerson-Hermannsdorfer-Sauerbruch diet, the content of sodium chloride is kept low, that of calcium and phosphate relatively high, and the diet is high in fat. It must be admitted that the results have been far from uniform. The diet that proves best for the child as a whole is undoubtedly the preferable diet with which to combat tuberculosis.



**Tuberculin Therapy.**—On the whole, tuberculin therapy has been disappointing, although beneficial results are occasionally seen, particularly in cases of phlyctenular conjunctivitis. Treatment is carried out by subcutaneous injections given twice or three times weekly. One must begin with very small amounts (0.001 milligram). The dose may be gradually increased unless a constitutional reaction is encountered. One should then go back to a smaller dose and advance more cautiously. Favorable results following tuberculin treatment have been attributed to (a) increased fibrosis about the tuberculous focus as a result of a mild inflammatory reaction induced by the tuberculin; (b) gradual desensitization with consequent diminution of the necrotizing effects of allergy. Although we are inclined to accept the latter explanation as the more plausible, with the prevailing uncertainty regarding the rôle of allergy in tuberculosis, this, too, must remain an unsettled question.

## CLINICAL FORMS OF TUBERCULOSIS

### I. ACUTE MILIARY TUBERCULOSIS

**Etiology.**—Miliary tuberculosis can usually be attributed to the erosion of a tuberculous focus into a blood vessel. Occasionally one finds at autopsy a large vessel—usually a vein—that has been eroded; more frequently it is a small venule that can be discovered only after the most painstaking search. Erosion of the thoracic duct is sometimes responsible for the introduction of bacilli into the blood stream. In most instances the focus from which dissemination takes place is in the lung or the bronchial lymph nodes, but it may be anywhere in the body.

In almost any form of tuberculosis, bacilli find their way into the blood stream from time to time. This has been demonstrated by blood cultures, and it is quite apparent from the pathological lesions that it must occur. Clinically, such episodes are occasionally revealed by the appearance of papulonecrotic tuberculids in the skin. The line between these occasional disseminations and what is known as acute miliary tuberculosis is not a sharp one; the distinction is one of degree only.

Miliary tuberculosis is more frequent in young children. There are several reasons for this. Many of these cases are primary infections in which the process has become widespread before the development of acquired resistance. A high degree of allergy accompanies primary infections, which favors widespread necrosis and, hence, dissemination. Lastly, childhood is *par excellence* the period of contagious diseases, and many of these—notably measles and whooping cough—lower resistance to tuberculosis.

**Pathology.**—The lesions in miliary tuberculosis show a certain amount of variation. There may be discrete miliary tubercles of the proliferative or of the caseous type (soft tubercles), the latter being more common in young subjects. In other instances there are larger lesions composed of four or five miliary tubercles which have coalesced; this is likely to be found when there has been extensive erosion of a vessel; bacilli are probably discharged in clumps rather than singly.

Miliary tubercles are most thickly distributed in the lungs, but they are also found scattered throughout other organs—especially the spleen, liver and kidneys. They may be found in any organ of the body. Tuberculous meningitis compli-



cated about three-fourths of the cases seen at the Harriet Lane Home, except during the first year of life, when more than one-third showed no meningeal involvement (Fig. 164). This finding bears out the contention of Rich and McCordock that tuberculous meningitis arises from the breaking down of a cerebral focus with discharge of bacilli into the spinal fluid, rather than from hematogenous dissemination of bacilli to the meninges.

**Symptoms.**—Miliary tuberculosis may occur in a well-nourished child apparently in good health, in whom there has been nothing to suggest tuberculous infection. This is more likely to be the case in infants. It may also develop in

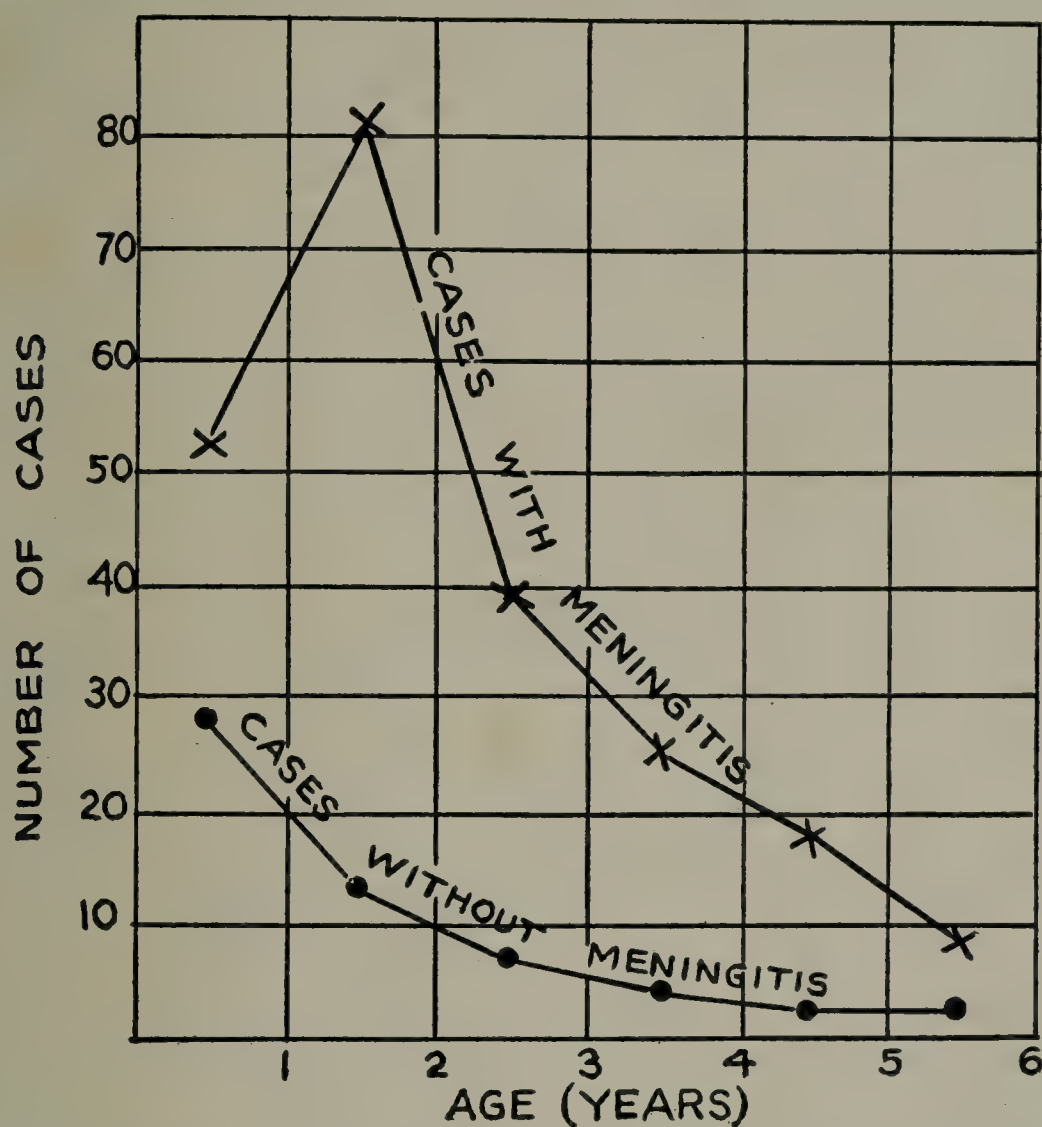


FIG. 164.—DEATHS FROM ACUTE MILIARY TUBERCULOSIS UNDER SIX YEARS OF AGE.

children with manifest tuberculosis whose nutrition has in consequence suffered severely. Constitutional symptoms are the most prominent feature of the disease—the only manifestation at the start. The onset is not abrupt, but can usually be dated within two or three days. There develop irregular fever and general symptoms of malaise, fretfulness and loss of appetite. The fever is usually of a hectic type with an afternoon rise to  $102^{\circ}$  or  $103^{\circ}$  F. and a morning remission. Sometimes a subnormal temperature is found in the early morning hours. At other times the daily fluctuations are less conspicuous—the temperature may remain between  $100^{\circ}$  and  $102^{\circ}$  F. Sustained high fever and marked prostration are quite exceptional. There is usually a moderate leukocytosis of 12,000 to 15,000 with a polymorphonuclear increase; toward the end the white count may be higher. There is tachycardia, usually in proportion to the fever. At this stage there is little to identify the nature of the infection. The symptoms persist, and with



temporary irregularities, they become increasingly severe. The spleen is nearly always enlarged; the liver frequently so. There may be gastro-intestinal disturbances, as in any acute infection. After a week or two mild respiratory symptoms develop. The breathing is slightly accelerated and fine râles may be heard in one or another part of the chest. These often disappear after a forced respiration or cough, suggesting that they are atelectatic in origin. As the disease progresses these râles become more constant and are usually found diffusely; signs of consolidation, however, are wanting. The duration of the disease varies from three to eight weeks, rarely somewhat longer than this. Toward the end, wasting and a moderate anemia may appear; prostration tends to increase. The respiratory symptoms, too, show progression. There may be dyspnea and cyanosis and perhaps a hacking cough, but the respiratory embarrassment is never extreme. Death usually occurs from circulatory failure; meningitis may, however, intervene at any time. There may be a terminal hyperpyrexia.

Typhoidal forms of the disease with a sudden onset, high fever, delirium, and extreme prostration are rare in early life. They are more likely to occur in older children.

**Diagnosis.**—Except in those cases complicated by meningitis, miliary tuberculosis is often unrecognized, being discovered only at autopsy. If the child is known to be tuberculous or to have been exposed to tuberculosis, the condition is more likely to be suspected and confirmatory evidence sought. In a small proportion of the cases there are cutaneous manifestations, the most common being papulonecrotic tuberculids. These may appear singly or in crops. A purpuric eruption—usually small petechiae—may be seen during the last week of the disease. This may be a nonspecific lesion, due to low platelets. Leiner and Spieler,<sup>6</sup> however, have reported instances in which sections of the purpuric lesion revealed large numbers of tubercle bacilli. Choroidal tubercles can be found in more than a third of the cases of miliary tuberculosis (Plate IV). They are often located at the periphery of the fundus, and hence can easily be missed in a casual examination. Sometimes only one or two are present; a frequently repeated search may be necessary to find one. Their presence is, however, of great diagnostic importance.

The tuberculin reaction is of great assistance. Allergy is often high in these cases unless the patient is moribund. An x-ray of the chest may not reveal the presence of miliary tuberculosis. Single discrete miliary tubercles cast no shadow. We have often seen the lungs studded with miliary tubercles at autopsy, while an x-ray picture taken a day or two before death showed no change whatsoever. The characteristic x-ray picture of "miliary tuberculosis" with a snowflake distribution throughout both lungs (Fig. 165) is, however, a common finding in these cases. The lesions which cast shadows are not single miliary tubercles but masses formed by the coalescence of several tubercles. This radiographic picture is very characteristic. The only other condition in children that may simulate it is the inhalation of powdered material—usually some dusting powder. Here the distribution of the lesions is not likely to be as uniform as in miliary tuberculosis; the periphery of the

<sup>6</sup> Leiner u. Spieler, *Ergebn. d. inn. Med. u. Kinderh.*, 1911, 7: 59.



PLATE IV



TUBERCLES IN THE CHOROID IN MILIARY TUBERCULOSIS.

The smaller of the two lesions is the more typical.







lung tends to be spared. The lesions are not so apt to be round, and they tend to be distributed radially. Moreover, the sudden onset of respiratory symptoms and the absence of the tuberculin reaction may serve to differentiate the condition, even in the absence of a definite history of aspiration.

Tubercle bacilli can be obtained by blood culture in a large proportion of cases of miliary tuberculosis but the organisms grow out so slowly that the method is of little practical importance. Bacilli are rarely recoverable from the sputum or

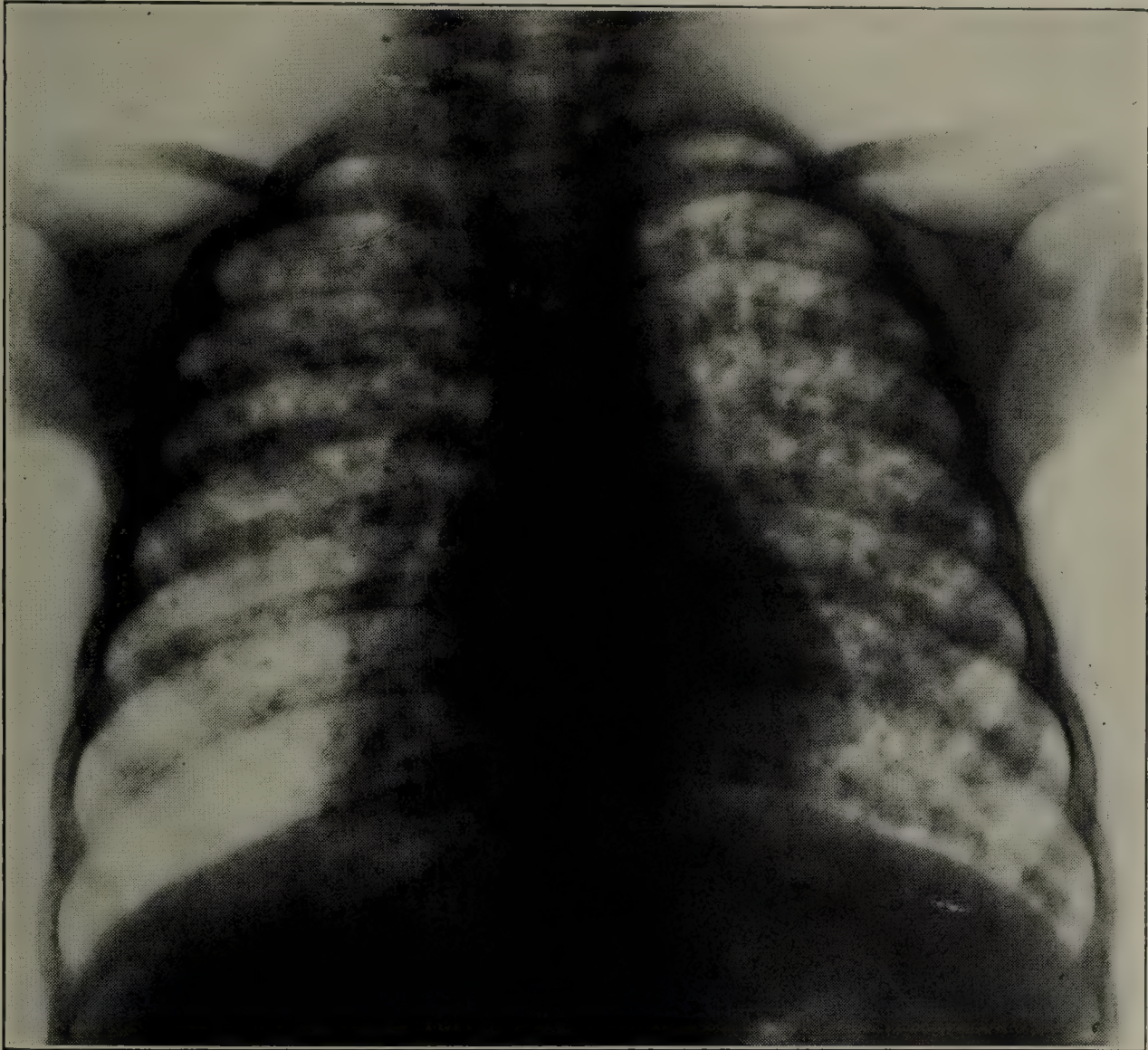


FIG. 165.—ROENTGENOGRAM IN ACUTE MILIARY TUBERCULOSIS.

An adopted child of three months of age, admitted for cough and fever of four days' duration. No known exposure to tuberculosis since adoption at age of one week. Physical signs of tuberculous meningitis, of which the patient died the day following admission. The lungs showed slight dulness over the left infraclavicular and suprascapular areas; no change in breath sounds. At autopsy widely disseminated miliary lesions were found. The primary focus was in the right lower lobe.

stomach washings, for in most instances the miliary lesions in the lungs are not open ones.

**Prognosis and Treatment.**—There are few diseases more fatal than miliary tuberculosis. Whether or not recovery ever occurs depends on one's definition of the disease. There can be no doubt that hematogenous dissemination of bacilli may occur without fatal results. One occasionally sees children—even infants—with one or more crops of tuberculids who go on to recovery. Cases are recorded in which recovery has taken place after the x-ray picture of miliary tuberculosis had developed. These reports are mostly in older children; we have ourselves seen one



such instance. However, with the clinical picture of miliary tuberculosis as it has been described above, recovery is not to be expected. The treatment is symptomatic.

## II. MASSIVE GENERALIZED TUBERCULOSIS

Here there are found extensive tuberculous lesions in various parts of the body. This form of generalized tuberculosis does not occur in infants, but may be seen after the second year. It is caused by a primary dissemination, probably temporary, which does not prove fatal. During the ensuing years the local lesions progress



FIG. 166.—LUNGS AND TRACHEOBRONCHIAL LYMPH NODES IN ACUTE MILIARY TUBERCULOSIS.  
Same patient as in Figure 165.

and may become very extensive. Such cases often terminate fatally with no evidence of miliary tuberculosis to be found at autopsy.

Symptoms of acute toxemia, fever, and leukocytosis are rarely conspicuous. Malnutrition may, however, reach an extreme degree. There is a poor appetite, great listlessness and often a marked anemia. In contrast to the miliary form of tuberculosis as seen in infants, local evidences of tuberculosis are not difficult to find—there may be involvement of the lungs, the abdomen, the bones, the lymph nodes or the genito-urinary tract. The clinical picture is largely determined by the local lesions. The cases may go on for years, now better and now worse. There may be clubbing of the fingers. Emaciation may become extreme. Amyloidosis is a complication which must be borne in mind. A fatal outcome may be determined by the extension of some local process, or by an intercurrent infection; some of



these patients succumb to asthenia. Miliary tuberculosis or tuberculous meningitis may of course terminate the picture at any time.

### III. PULMONARY TUBERCULOSIS

The manifestations of pulmonary tuberculosis in childhood are quite varied. We shall take up a number of different forms separately, bearing in mind that the distinction between them is not always a sharp one.

**Primary Tuberculous Infection (Tuberculosis of the Childhood Type).—**The characteristics of a primary infection in childhood have been described elsewhere: (1) with lack of acquired resistance the organisms spread readily from the portal of entry to the regional lymph nodes and perhaps beyond; (2) as resistance develops, a high degree of allergy also appears, with the result that acute inflammatory lesions, often with necrosis, are found instead of the slow proliferative response; (3) necrosis and ulceration increase the likelihood of dissemination through erosion of blood vessels, bronchi, or other hollow viscera.

Not all primary infections reach the lung. If the intestine is the portal of entry and the infection is not a severe one, it may not pass beyond the regional lymph nodes. In the great majority of instances, however, regardless of the portal of entry, organisms reach the lungs at an early date—either directly or by way of the circulation. There follows a definite chain of events; the resulting lesions are, however, modified to some extent by the severity of the infection.

*Mild Primary Infection (Latent Mediastinal Tuberculosis).*—It is often stated, particularly in the German literature, that a primary focus invariably develops in the lung at the point where tubercle bacilli first lodge—usually in the lymphatic tissue of the lung itself. Attention was first called to these primary foci by Parrot, Ghon and others, and there can be no doubt of their common occurrence. However, they are not always demonstrable, particularly in light infections where the number of bacilli introduced is probably small. It has been shown in animals, and appears to be equally true in man, that bacilli in small numbers can pass out of the lung without producing a lesion and be caught in the tracheobronchial lymph nodes. Certainly it is common enough to find at autopsy, in patients dying from some other cause, a tuberculous lymph node with no corresponding pulmonary lesion. Whether in such instances there has been in the past a minute lesion that is completely healed is a matter of academic interest only.

In the great majority of individuals—whether children, adolescents or adults—primary tuberculous infection is a subclinical affair, passing unnoticed unless the individual is being followed by x-ray or by the tuberculin reaction. Even in young infants this holds true. When a subject who has been exposed to tuberculosis is followed closely by these means, no evidence of the disease can be detected for a period varying from three to thirteen weeks. In most instances, between the fourth and seventh week the skin test becomes positive and enlargement of hilar lymph nodes or focal infiltration of the lung parenchyma can be detected by x-ray. The lymph nodes are the seat of a tuberculous inflammation that may go on to caseation. They enlarge rapidly during ensuing weeks and then retrogress slowly during the following months and years, until eventually little or no evidence of the infection may be visible in the x-ray. The degree of allergy is roughly parallel to



the enlargement of the lymph nodes; as these diminish in size allergy gradually wanes but does not disappear altogether.

It would be idle to deny, as some have claimed, that a minute pulmonary focus is present in most of these cases, too small to cast a shadow in the x-ray. This is probably true, but it does not alter the fact that *mild* primary tuberculosis is, by and large, a disease of the tracheobronchial lymph nodes.

Primary tuberculous infection such as has been described may, of course, be interrupted at any point by some factor which lowers resistance and permits the process to flare up and spread.

*More Severe Forms (Primary Tuberculosis of the Lung).*—With a heavier primary infection bacilli lodge in the lung itself and produce a well-defined lesion. This does not mean that the bronchial lymph nodes in any sense escape; on the contrary they suffer more severely than in mild forms. The primary focus may be located in any part of the lung, usually in the vicinity of a terminal bronchus. Drainage from this focus by the lymphatics leads to infection of the lymphoid nodules of the lung itself and to extensive involvement of the tracheobronchial lymph nodes. With the advent of allergy a severe inflammatory reaction is set up in the lung about the primary focus, and the swelling of the nodes at the hilum may be very great. These perifocal tuberculous pneumonias may last a long time, subsiding gradually during the course of years. Necrosis does not always occur, though in most cases there is some caseation. There may be an extensive caseous pneumonia with cavitation if the infection is an overwhelming one. Usually only a small central portion of the inflammatory area becomes necrotic and subsequently heals by fibrosis or calcification. These fibrous scars or calcified nodules can often be seen years later, marking the site of the primary focal infection.

Infections of the kind just described usually give clinical manifestations. At the height of the inflammatory reaction there is fever—the so-called *initial fever*, described first by H. Koch. This may be a transient phenomenon lasting only a few days, or it may persist for weeks; it is usually not high. There are other constitutional symptoms—malaise, loss of appetite and perhaps minor digestive disturbances. Such an episode may be dismissed as a grip-like infection. Signs in the lungs are often negligible; rarely is there more than slight dulness and suppression of breath sounds. This is in sharp contrast to the x-ray findings, which reveal greatly enlarged mediastinal nodes and a variable amount of pulmonary consolidation. The pulmonary consolidation usually adjoins the hilum; it may take the form of a band connecting the hilum with a peripheral portion of the lung; there may be a triangular shadow with its base resting on the hilum. Sometimes there is a rounded bulging shadow, outwardly convex, contiguous with the hilum and extending outward into the lung. The height of the allergic reaction coincides with the febrile period and with the maximum extent of the pulmonary lesion.

Other manifestations that may occur at the height of the process are *phlyctenular conjunctivitis* and *erythema nodosum*. Either of these lesions should suggest a tuberculous process. Phlyctenular conjunctivitis is not itself a tuberculous lesion; it has been regarded as an allergic response to products of tubercle bacilli, although this has never been proved. It is a common lesion in this country, and it is doubtful, in children at least, if it ever occurs in conditions other than tuberculosis. It is not



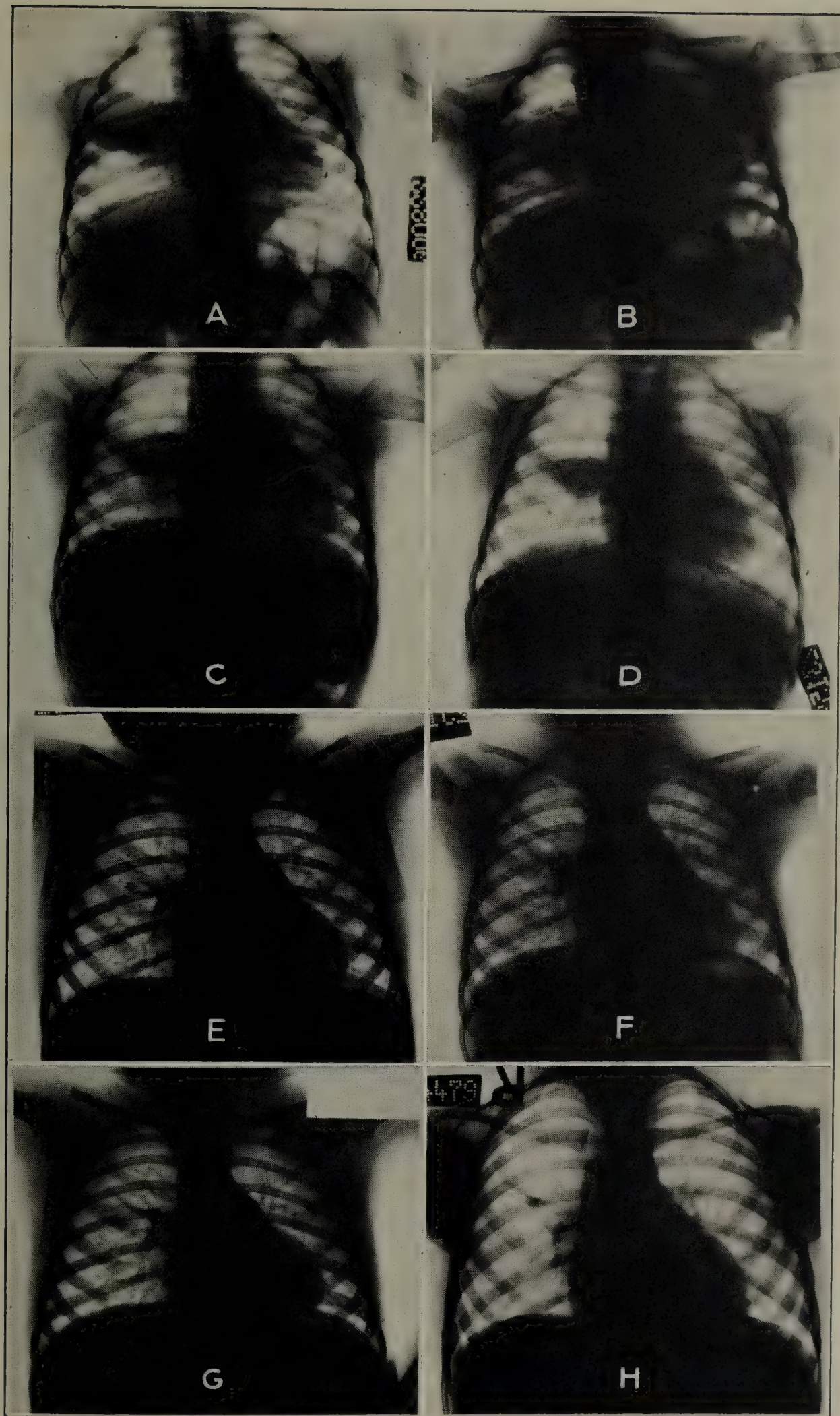


FIG. 167.—ROENTGENOGRAMS SHOWING EVOLUTION AND RESOLUTION OF A PRIMARY PULMONARY FOCUS.

The course of a perifocal reaction ("epituberculosis") is shown:

A—20 months  
C—21 months  
E—2½ years  
G—4 years

B—20½ months  
D—21½ months  
F—3 years  
H—5 years



confined to the stage of invasion, but may recur subsequently. Erythema nodosum is not a tuberculous lesion either, and this too has been regarded as an allergic response. In this country erythema nodosum is a rare condition and is often unrelated to tuberculosis. Reports from Scandinavia and northern Europe indicate that erythema nodosum is very common there, and that nearly all cases are associated with primary tuberculosis.

Tubercle bacilli can often be recovered from the fasting stomach washings at the height of these perifocal reactions; they may be found even before this. Ligner has detected organisms in the washings from a patient as early as eight days before fever and a positive skin test appeared.

The course of these perifocal tuberculous pneumonias is variable. The febrile reaction often lasts but a week or two, and retrogression of the lesions and the allergic response follows gradually thereafter. The accompanying history and roentgenograms (Fig. 167) indicate the course in a case of moderate severity:

F. O'H., during the greater part of his first year, was exposed to a tuberculous uncle. At eleven months of age he had a febrile upper respiratory infection, from which he made a rapid recovery. At nineteen months he developed irregular, unexplained fever; the lungs were still clear but the tuberculin reaction had become strongly positive (film A). During the twentieth and twenty-first months, he had irregular fever, sometimes as high as 104° F., accompanied by cough and chest signs: dulness, diminished breathing, a transient friction rub and inconstant râles in the right axilla, all of which gradually diminished in the course of two months. In spite of this episode, he gained 5 pounds in five months, weighing 27 pounds at twenty-six months. From the twenty-seventh to thirtieth month there was slow gain, accompanied by a transient tuberculous episcleritis. Throughout the third year he tended to show an occasional temperature above 100° F. In spite of various infections—otitis media, numerous colds, an attack of catarrhal jaundice, measles and pertussis—the patient continued to do moderately well. At the age of five years he weighed 38½ pounds, was afebrile and had no complaints.

With a *heavy infection*, however, this favorable outcome may not occur. The primary lesion is extensive and constitutional symptoms may last for months. Necrosis may result in a caseous pneumonia; there may be erosion of a bronchus causing dissemination in the lung itself, or there may be erosion of a blood vessel with a terminal miliary tuberculosis. As Epstein has put it, the initial fever may become the terminal fever as well. Even with infections which are apparently benign and progressing favorably there is always the possibility of relapse and spread—as indeed with any form of tuberculosis anywhere.

*Epituberculosis*.—This term has been applied to a form of tuberculosis seen in young children which is characterized by mild constitutional symptoms and an extensive area of pulmonary consolidation. It runs a chronic course, eventually undergoing gradual resolution. Such cases are by no means rare; we have seen a number of them. Fever and other constitutional symptoms are usually slight; cough is mild or absent. On physical examination there may be signs of consolidation, but frequently the condition is discovered by x-ray. The shadow cast is all out of proportion to the paucity of physical signs. The involved area is sharply demarcated from the surrounding lung, and presents a rounded, externally convex, smooth outline. It extends outward from the mediastinum and may involve the greater part of one or more lobes. Eliasberg and Neuland, who first described



epituberculosis, failed to recover tubercle bacilli from such cases; they regarded the condition as a nonspecific pneumonia surrounding a tuberculous focus; such a focal lesion often becomes evident as the process subsides. Although very few pathological observations have been made, such evidence as there is indicates that epituber-

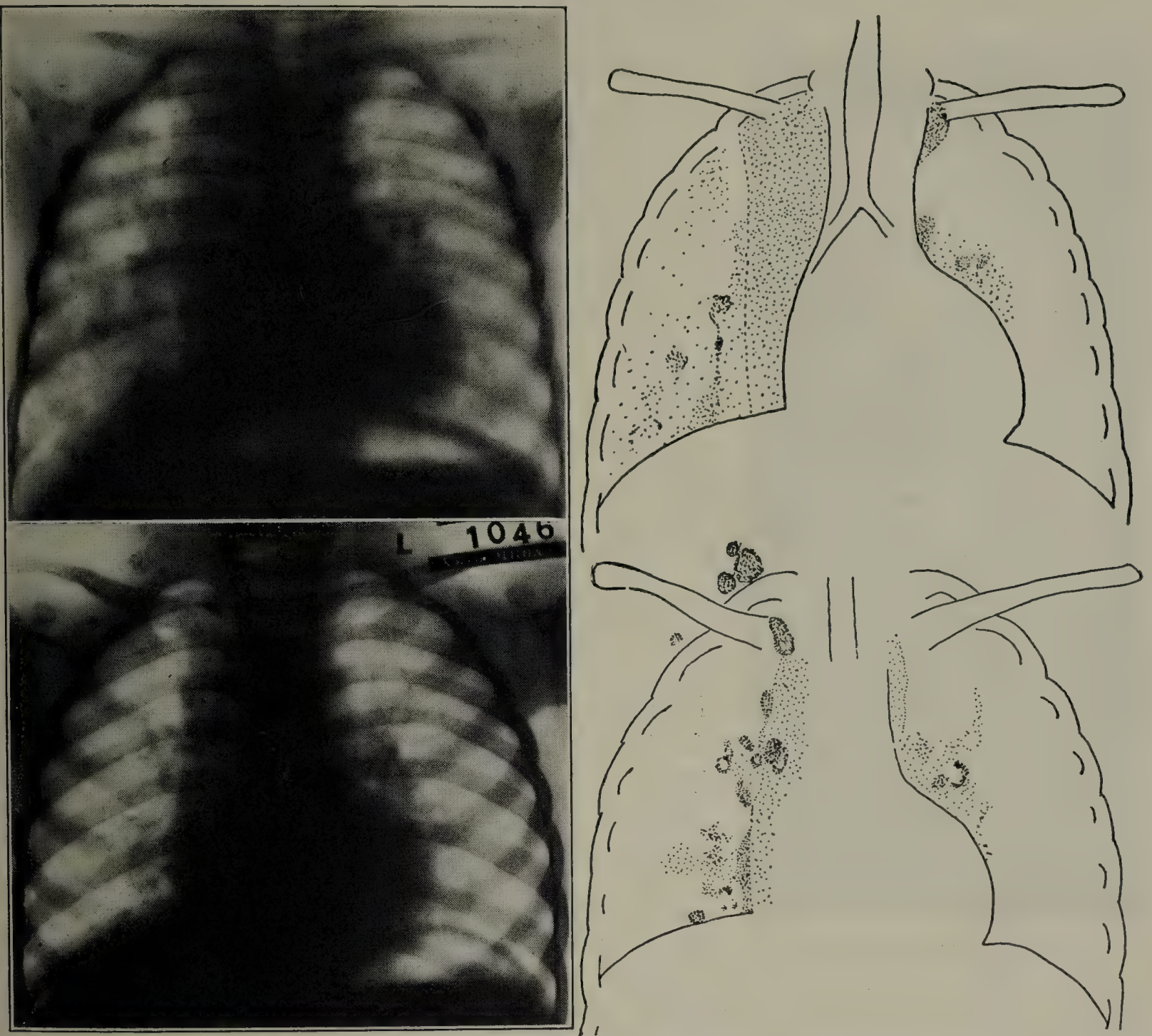


FIG. 168.—EXTENSIVE PULMONARY INVOLVEMENT IN EARLY LIFE, WITH RECOVERY.

Patient exposed to tuberculous father in early infancy. At six months of age developed fever, cough and listlessness, which did not improve. Seen at seven and a half months (upper film): acutely ill, rapid respiration, signs of diffuse bronchitis with questionable consolidation at right base. Gradual improvement. Tonsils and adenoids, removed at two and a half years, showed evidence of tuberculosis. Patient was then symptom-free. X-ray (second film) showed diminution of the wide mediastinal shadow and the appearance of numerous calcified foci both inside and outside of the thorax. The primary focus, from which the widespread early dissemination took place, now shows as a densely calcified shadow just above the right diaphragm.

culosis is merely primary tuberculous pneumonia in which little necrosis takes place. Recent studies have shown that by animal inoculation of gastric washings bacilli can usually be recovered.

Although the original view of Eliasberg and Neuland that this process was a nontuberculous inflammation has not been substantiated, their observations were of



great value in calling attention to the fact that tuberculous pneumonia was not necessarily caseous pneumonia, and that many of these processes were benign and underwent resolution.

**Tuberculous Pneumonia.**—The primary perifocal tuberculous pneumonias have been described. In the great majority of instances these progress favorably, but if the infection is an overwhelming one there may be extensive caseation and cavitation with a fatal outcome.

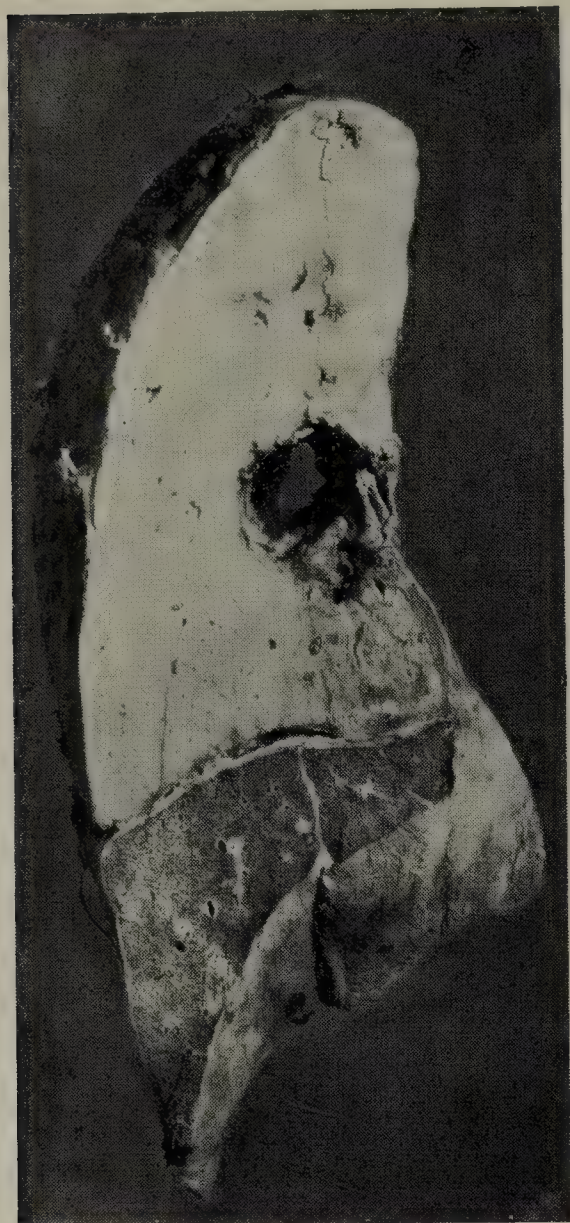


FIG. 169.—TUBERCULOUS PNEUMONIA.

A vertical section through the middle of the right lung of a child thirteen months old. The greater part of the upper lobe is uniformly caseous—a diffuse tuberculous pneumonia; near the center the commencement of a cavity is seen; below, it has the appearance of a consolidation from simple pneumonia. The part of the lower lobe shown is normal (see Figure 170).

Secondary tuberculous involvement of the lung may occur in a number of ways. There may be dissemination of bacilli by the blood stream, giving rise to miliary tuberculosis, or to larger conglomerate lesions. The lung may become involved by direct extension outward of a process in the tracheobronchial lymph nodes. Lastly, erosion of a bronchus may cause massive involvement of the area which it supplies, with more or less dissemination elsewhere. Obviously the lesions can vary greatly in their distribution and in their character. Necrosis may be negligible or may be extensive, depending upon the number of organisms present and the degree of allergy. The factors which permit the extension of a tuberculous process in the lung are those which lower *general* resistance. Infectious diseases are of particular importance. Whether infections of the respiratory tract have a deleterious influence on *local* as well as general resistance is not known.

As might be expected there is little constancy in the clinical picture of tuberculous pneumonia. The process may be continuous with the primary infection or may develop years after this has been quiescent. The most common form of localized pulmonary tuberculosis in young children is caused by extension from the tracheobronchial lymph nodes. The onset of the process is insidious. We have followed such cases by x-ray and watched the lesion spread from the hilum to the periphery of the lung with almost no constitutional symptoms and few physical signs. There may be only localized râles and no definite signs of consolidation until the lesion has become quite large.

With a rapidly spreading process symptoms are usually more pronounced. There is an irregular fever which shows considerable diurnal variation and often unexplained fluctuations over longer periods. Such a fever following an infectious disease like measles or pertussis is always suspicious. Sweating is common in



older children but of little diagnostic value. There may be pallor—not necessarily associated with anemia—progressive weakness, irritability and loss of weight. With fever and steady loss of weight tuberculosis should always be suspected no matter how indefinite the other symptoms may be. The spleen is enlarged in most instances. Cough is usually present. The cough of a tuberculous pneumonia is often mild as compared with many cases of chronic bronchitis and chronic nontuberculous pneumonia. Occasionally there is a hard paroxysmal cough, which usually depends upon the presence of enlarged mediastinal glands. Hemoptysis in children is almost unknown. As the involvement extends, the respiration becomes rapid and

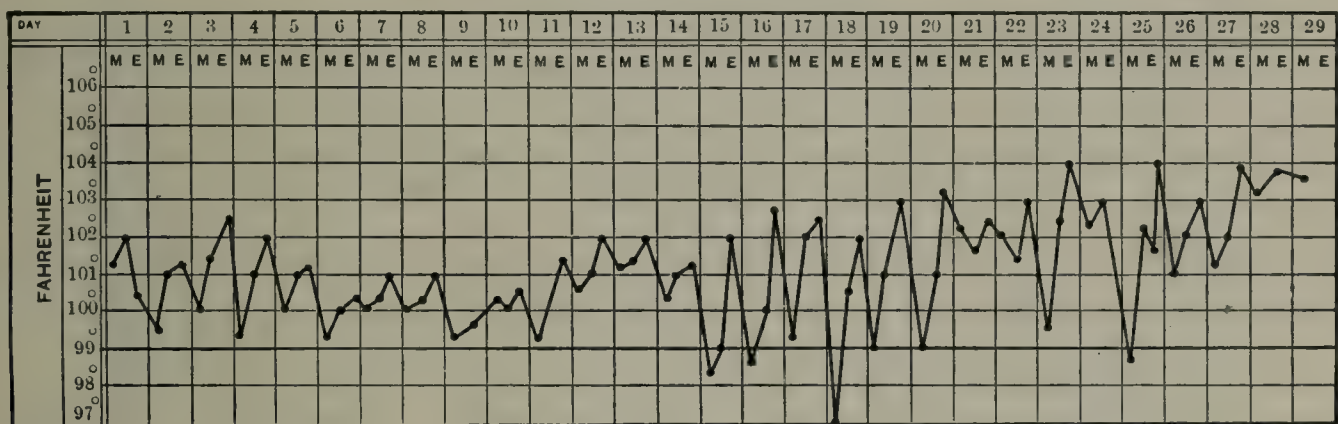


FIG. 170.—TUBERCULOUS PNEUMONIA WITH EXTENSIVE SOFTENING AND CAVITATION.

Infant thirteen months old; weight, 10 pounds; came under observation four weeks before death, with consolidation at apex of right lung. Signs increased in intensity, and extended in area until there were heard, from clavicle to below the nipple, exaggerated bronchial voice and breathing and many moist râles; percussion note was flat; behind, the same signs at extreme apex. No distinct signs of a cavity; no hectic fever; no sweating. Autopsy showed large cavity at right apex partly filled with caseous masses; diffuse caseous pneumonia (Fig. 169) of the rest of right upper lobe, with scattered foci in the rest of the lungs and a few in the abdominal organs.

dyspnea becomes constant; there may be cyanosis. There are definite signs of consolidation on physical examination.

When tuberculous pneumonia follows ulceration of a bronchus, the process is usually fairly rapid in its development. A massive pneumonia develops in the portion of the lung supplied by the bronchus, which appears in the x-ray picture as a wedge-shaped shadow with the base out. There is also widespread dissemination by means of the bronchial tree to other parts of the lung and to the opposite lung.

In general, tuberculous pneumonias differ from simple pneumonias in their more gradual onset, and in the fact that constitutional symptoms and physical signs are less marked than one would expect from the extent of the consolidation. The x-ray is sometimes helpful but by no means infallible. The greatest emphasis must be placed on the value of the skin test in the recognition of these tuberculous conditions in young children.

The prognosis in tuberculous pneumonia is always highly uncertain, the chief difficulty being that it is impossible to determine—either clinically or by x-ray—how much of a consolidated area has undergone, or will undergo, necrosis. Resolution can occur with extensive areas of consolidation. If there is evidence of cavitation or if bacilli are recovered in large numbers these are unfavorable signs, but do not imply an absolutely bad prognosis. The outcome cannot be satisfactorily predicted from a single examination. The general course of the patient, his weight



curve, and above all repeated x-ray examinations are necessary to form an idea of what is happening. A fatal outcome may be determined by the extent of the pulmonary disease or by the development of miliary tuberculosis or meningitis.

**Chronic Fibroid Tuberculosis (Tuberculosis of the Adult Type).**—In contrast to the acute inflammatory lesions described above are the chronic progressive forms of tuberculosis seen in adults. In the latter allergy is not extreme; the lesions show little evidence of acute inflammation, but are characterized by extensive fibrosis. The distinction between the two types is not a sharp one; all sorts of intermediate forms are seen, and the primary childhood type may pass into the adult type by almost imperceptible changes. The extremes of the two conditions can, however, be readily distinguished both pathologically and clinically.

Chronic fibroid tuberculosis does not occur in young children. It is occasionally seen in the latter half of the first decade and becomes increasingly more frequent as puberty approaches.

The clinical picture may resemble very closely that of a nontuberculous chronic interstitial pneumonia. These cases have usually had their origin in one of the acute forms of childhood tuberculosis. There is a slow convalescence and almost complete clinical recovery. A slight cough may persist, however, or may return in the presence of upper respiratory infections. The child remains underweight, and a careful examination of the lungs shows some abnormal signs, perhaps only localized râles. The x-ray may reveal irregular shadows in the affected region.

The process may flare up from time to time with fever, increased cough and some extension of the local lesion. When the general symptoms once more subside, the local process is found to have maintained its increase in size. Often there are several such flare-ups during a winter; they may pass unrecognized, being regarded as bronchitis or ordinary pneumonia. The lesion may be found in any part of the lung, somewhat more frequently in the upper lobes. Clinically and by x-ray it may be difficult to distinguish these cases from nontuberculous chronic pneumonia. A positive tuberculin reaction in older children has little significance. Bacilli may be recovered if carefully searched for. The course, the treatment and the prognosis do not differ materially from cases of nontuberculous origin. Sometimes they are terminated by acute disseminated tuberculosis or caseous pneumonia.

Typical *chronic phthisis* with its chronic hectic fever, slow cavity formation, progressive emaciation, night-sweats, etc., is rarely seen before the eighth year, and is not at all frequent until after puberty. It may result from reinfection from without rather than reactivation of an old latent focus; it often develops in the opposite lung from that exhibiting a primary focus. The symptoms, course, termination and physical signs do not differ from those seen in adults.

**Special Manifestations.**—*Cavitation.*—Cavities large enough to deserve the name were present in about half of our autopsies on tuberculous patients, two years of age and under. They vary in size from a cherry to a hen's egg, and sometimes a much larger one is seen. They are usually rather deep-seated, but rarely they may perforate the pleura causing pneumothorax or pyopneumothorax. It is rare in a young child to find cavities surrounded by dense fibrous walls such as are seen in older children or in adults; in infancy the process of softening, once begun, usually advances rapidly.



Small cavities are usually partially filled with caseous material and rarely communicate freely with a bronchus; hence they do not, as a rule, give physical signs. If large and superficial they give the same signs as in adults. In the young child similar signs are often present when there are only dilated bronchi associated with a fibroid condition, or when a superficial bronchus is surrounded by an area of diffuse caseation. Cavities are often diagnosed when they do not exist, and quite as often overlooked when present. As a rule, they can readily be detected by x-ray (Fig. 171); but even with this aid an emphysematous bleb or an area of

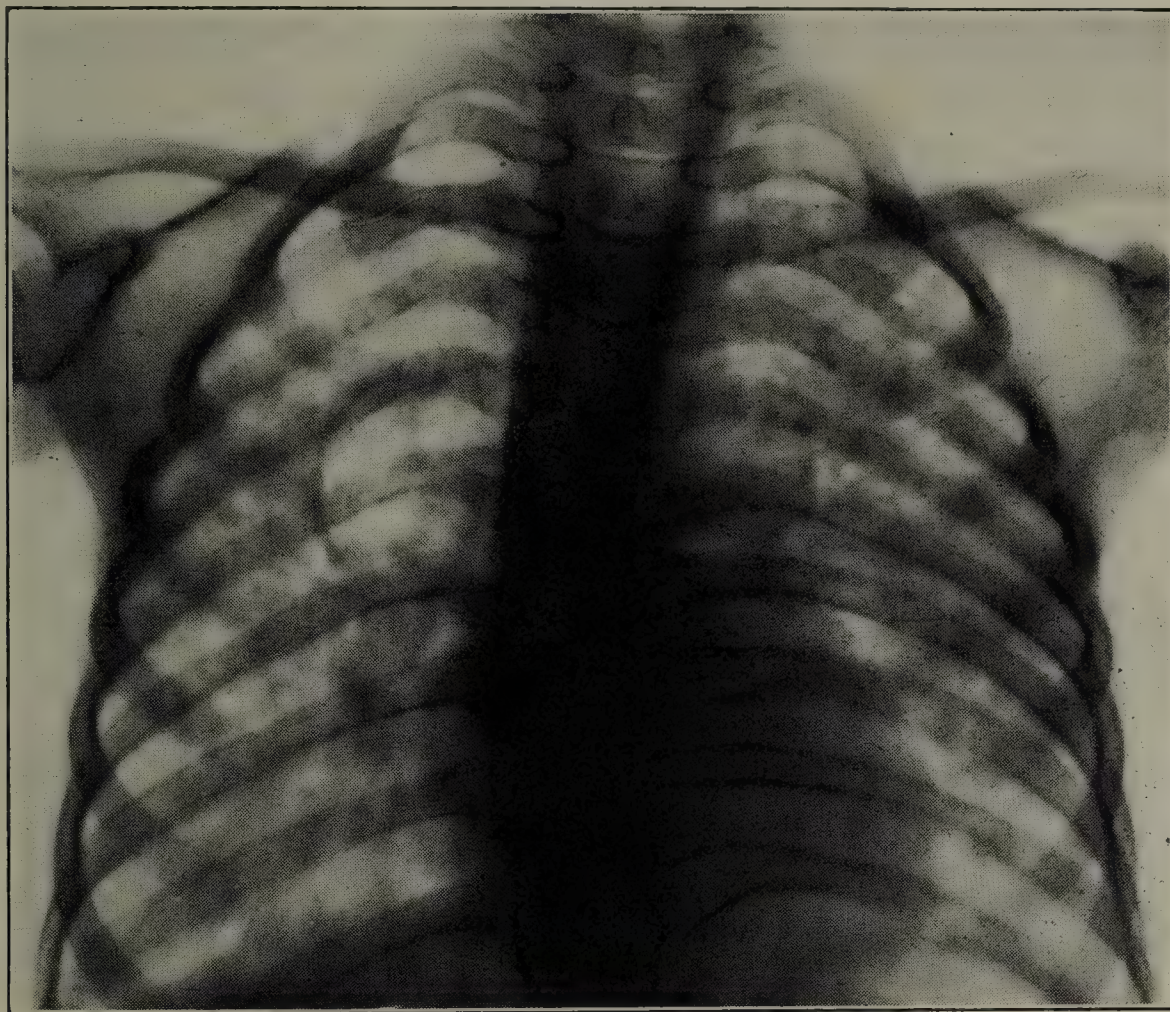


FIG. 171.—TYPICAL THIN-WALLED TUBERCULOUS CAVITY IN A CHILD FOUR YEARS OLD.

Death from acute miliary tuberculosis shortly after this picture was taken.

pneumothorax walled off by adhesions may cause confusion. Plates made in several planes may enable one to distinguish a genuine cavity.

*Pleurisy.*—It is rare to find the pleura normal in autopsies on children who have died of tuberculosis. In miliary tuberculosis the visceral pleura is generally studded with tubercles, and in most instances of extensive pulmonary disease there are fibrous adhesions over the affected portion of the lung; the amount of thickening, however, is seldom great. Small accumulations of serofibrinous exudate are not infrequent; they are often unrecognized during life, for the signs are usually masked by those of the adjacent pulmonary lesion. Sometimes the x-ray reveals a small collection of exudate at the surface of the lung. There may be interlobar pleurisy; this can be recognized only by the x-ray. Wallgren has shown that if anteroposterior exposures are taken in two diagonal planes—one in the plane of the fissure and the other perpendicular to it—interlobar pleurisy in the first instance appears as a dense narrow band, and in the latter as diffuse clouding.

Curiously enough it is rare to find in children, as one so commonly does in



adults, a large serous effusion with minimal evidences of disease in the lung itself. We have, however, seen this as early as three years of age.

*Pneumothorax*.—This is a relatively infrequent occurrence in children with tuberculosis; it is rarely seen under three years of age. It is usually caused by extension of a small cavity through the pleura, and may be associated with a serofibrinous effusion. The signs of pneumothorax and pyopneumothorax are described elsewhere. The development of sudden dyspnea and cyanosis in a tuberculous patient should lead one to suspect pneumothorax. Similar symptoms may be caused by rupture of a caseous focus into the trachea or a primary bronchus.

*Tuberculosis of the Tracheobronchial Lymph Nodes*.—The regularity with which these nodes are involved in primary infections has already been emphasized. Even though the enlargement is considerable, it is in our experience quite exceptional to encounter local symptoms. Occasionally one does find in very young subjects a brassy cough, but most of the patients with marked local symptoms are over two, usually between three and ten years old. They have generally had a smoldering activity of the disease process over a period of years; it is more common to find gland symptoms in children who have relatively inconspicuous lesions in the lung parenchyma. Marked glandular involvement in the mediastinum is not infrequently seen in patients who have other comparatively slow-burning forms of the disease—tuberculosis of the bones, of the cervical lymph nodes, lupus, or abdominal tuberculosis. Symptoms directly referable to tracheobronchial lymph node involvement may be caused by irritation of adjacent nerves—the vagus and the phrenic—by perforation of, or pressure upon, the trachea or bronchi or other hollow structures, or there may be the more remote manifestations of a cold abscess in the mediastinum.

Enlarged lymph nodes, either by their influence upon the nerves or by direct irritation from pressure upon the trachea and bronchi, produce cough, dyspnea, and sometimes a change in the voice. The cough is persistent and teasing, and frequently occurs in paroxysms which in many respects resemble those of pertussis, but it usually lacks the characteristic whoop, and is not accompanied by the expectoration of a mass of tenacious mucus. These paroxysms are severe and prolonged. The cough often has a curious ringing, brassy character which is readily recognizable; it has been described as a “bitonal” cough. The dyspnea, like the cough, is paroxysmal, and sometimes strongly resembles ordinary spasmodic croup; at other times it is like a severe attack of asthma. It is more striking on expiration than inspiration and in infants is often accompanied by much rattling and wheezing in the trachea and bronchi. Such symptoms may come and go, but they are frequently prolonged, and usually in the interval between attacks the patient is not wholly free from dyspnea. When one of the primary bronchi or a lobar bronchus is compressed, there may be a corresponding asymmetry of the physical signs. The x-ray may show either emphysema or atelectasis of the portion of lung supplied, depending on the completeness of obstruction produced.

Sometimes, after these symptoms have persisted for days or weeks, and in other instances without warning, there occurs a sudden attack of asphyxia which may prove fatal. This is generally due to ulceration of a caseous node into the trachea or a large bronchus, where it produces the same effects as any other foreign body.



Rarely after such an episode the patient has recovered spontaneously after coughing up a large amount of pus.

In the following case, prompt surgical intervention apparently saved the patient from suffocation:

A sixteen-months old child developed croupy respiration following a common cold. He was admitted to the hospital with the diagnosis of acute laryngitis and was treated accordingly. Five days later he suddenly developed extreme inspiratory and expiratory dyspnea with cyanosis and collapse. The breath sounds were diminished in both lungs. Dyspnea failed to respond to intubation and tracheotomy, but suddenly cleared up with the aspiration of flaky material and a caseous plug by catheter through the tracheotomy tube. Tubercle bacilli were demonstrated in this caseous plug. During the ensuing two weeks the patient ran an irregular fever and had occasional dyspneic attacks similarly relieved by aspiration. Bronchoscopy showed an area of granulation at the bifurcation, apparently marking the site of a sinus communicating with a caseous node. The x-ray showed enlarged mediastinal nodes with some pulmonary infiltration and interlobar pleurisy. The patient made an uneventful recovery with retrogression of the lesions in the lung and lymph nodes.

Rupture of a caseous focus into a bronchus does not necessarily occur with such suddenness; it may be a very gradual process accompanied by little or no dyspnea.

Involvement of the phrenic nerve by the tuberculous process may cause paralysis of the diaphragm; it is usually unilateral. Often this can be detected clinically by close observation of the abdomen. The diagnosis is readily confirmed by fluoroscopy.

Pressure upon the superior vena cava may cause edema and cyanosis of the face. Cases have been reported with erosion of the great vessels, and sudden death. Pressure upon the esophagus may cause dysphagia. The caseous mass may perforate the esophagus or the pericardium. If ulceration takes place into the surrounding connective tissue, a mediastinal abscess may result producing any of the pressure symptoms noted above. Such an abscess may point in the suprasternal notch, or between the ribs anteriorly at the xyphoid. It may burrow along the esophagus to the peritoneal cavity. As a rule, however, death occurs from disseminated tuberculosis before the local conditions have advanced so far. Patients with tuberculous mediastinitis may survive a long time; improvement may occur, but is rarely continuous; dense fibrous adhesions may form about tuberculous foci. The clinical picture of adhesive mediastinitis, sometimes known as Pick's disease, is described elsewhere.

Only large masses of lymph nodes can be made out by physical signs. The important signs are retromanubrial dulness, paravertebral dulness between the first and fifth dorsal spines and a positive d'Espine's sign.<sup>7</sup> None of these signs is infallible. They may be absent when there are extensive masses and one or more of them may be positive when the x-ray reveals no enlargement. The d'Espine sign is the most reliable of the three.

Signs of *bronchial compression* may be due to enlarged lymph nodes; they may also be due to contraction of scar tissue in an old fibroid process. With partial bronchial obstruction there is diminished breathing over the affected area. Com-

<sup>7</sup> Normally the bronchial whisper (or bronchial voice) is lost below the first or second thoracic spine. If it extends down to the fourth or fifth thoracic spine, d'Espine's sign is said to be positive.



plete bronchial obstruction is usually the result of plugging with a caseous mass; it rarely results from outside pressure. Here there is absence of the respiratory murmur over a lobe or perhaps the entire lung. In this latter condition the lung soon becomes atelectatic, and the mediastinum shifts toward the affected side. This is the so-called "massive collapse" of the lung; it is not difficult to recognize but is seldom present.

**Diagnosis.**—Pulmonary tuberculosis should be considered whenever there is a suspicion of tuberculosis in the environment; when there is unexplained persistent fever, loss of weight or other constitutional symptoms; when there is a chronic or recurring cough, particularly after infections like measles and pertussis. It should be thought of when there is a lesion elsewhere that might possibly be tuberculous, and whenever phlyctenular conjunctivitis or erythema nodosum are present. Any one of these circumstances calls for a tuberculin reaction and an x-ray of the chest, even if physical examination of the chest is negative.

Early tuberculosis cannot be satisfactorily detected by physical signs, even in the best hands. When signs are present they may give valuable information, but without a tuberculin reaction and x-ray one cannot feel secure in the management of a clinical problem in tuberculosis.

These diagnostic aids supplement each other; either one alone may give conclusive or indecisive evidence. Miliary tuberculosis and old calcified foci give pathognomonic x-ray pictures, but other shadows must be interpreted in the light of experience and in relation to other findings. A positive tuberculin reaction in an infant with pulmonary or mediastinal shadows is presumptive evidence that the lesions are tuberculous. This probability decreases with age. When tubercle bacilli can be recovered from the fasting stomach contents, this is of course conclusive evidence of an open pulmonary lesion. This procedure is a most valuable one in children under six, who usually swallow their sputum.

The x-ray shadow of tuberculous mediastinal lymph nodes presents nothing pathognomonic unless calcification is present. The outline of such a cluster of nodes may be straight or convex, smooth or scalloped. In the young infant these may be confused with a thymus shadow. The latter, however, always presents a smooth outline; it may be either straight or convex; adjacent infiltration of the lung does not occur. The tuberculin test is, of course, of great importance here, but even with a positive tuberculin test the possibility remains that part of such a shadow may be due to the thymus.

In older subjects Hodgkin's disease or lymphosarcoma may give mediastinal glandular enlargement similar to tuberculosis. These are rare conditions in children and present other characteristic features; the glandular enlargement is usually more marked, and there is no tendency to calcification.

One of the greatest difficulties in diagnosis lies in distinguishing slight degrees of tuberculous infiltration at the hilum from the normal root shadows which become increasingly prominent with age; the latter may be very striking in subjects who suffer from bronchitis and asthma. Here there is no substitute for the experience gained in reading many plates in tuberculous and nontuberculous subjects. Enlarged lymph nodes and old calcified foci favor the diagnosis of tuberculosis.



The most confusing pictures are those which may be found with pneumonias undergoing delayed resolution, interstitial bronchopneumonias and those due to foreign bodies. The clinical and roentgenological characteristics of pneumonias due to the aspiration of lipoids have been described elsewhere.

Tuberculous pneumonias must at times be differentiated from acute pyogenic pneumonia, empyema, chronic pneumonia, lung abscess and foreign body reactions. The specific diagnostic methods are usually decisive. Some of the most confusing cases are those in which a tuberculous patient develops an acute pneumonia. Here one is never certain whether one is dealing with a superimposed pyogenic pneumonia or a sudden flare-up of the tuberculous process. Often only the subsequent course will make it clear.

**Prognosis.**—It is not possible to generalize about the prognosis of pulmonary tuberculosis in children. The general belief that tuberculosis in young infants is a highly fatal disease is being abandoned the more these infections are studied. Beyond question a large proportion of these infants survive.

The prognosis in individual cases must be judged by clinical progress—fever, constitutional symptoms and especially the weight curve. The progress of the local lesion as revealed by the x-ray has proved an invaluable prognostic guide.

Even in the face of continuing improvement, however, it is well to give a guarded prognosis. Untoward developments may occur when least expected.

**Treatment.**—The general hygienic and dietetic measures have been discussed elsewhere. There remain such local measures as can be applied in particular forms of the disease.

Reports in the literature, those of Armand-Delille in particular, would seem to indicate that the production of artificial pneumothorax has been of benefit to a small number of children with pulmonary tuberculosis treated by this means. Extensive pleuritic adhesions often make this method difficult of application or impossible. The indications for its employment are much the same as those for adults but the common tuberculous lesion in childhood, tuberculous pneumonia, is not so likely to be beneficially affected as are the more slowly progressing tuberculous lesions of adult life. Artificial pneumothorax should be employed only by those who have the experience and the skill necessary for its successful production. The same considerations apply to destructive operations upon the phrenic nerve.

#### IV. TUBERCULOSIS OF THE HEART AND PERICARDIUM

In acute miliary tuberculosis, tubercles are occasionally found in the myocardium; larger lesions are very exceptional. Miliary tubercles and minute caseous foci are in rare instances seen upon the mural endocardium, most frequently in the conus arteriosus of the right ventricle. One of our cases in an infant sixteen months old had such lesions in both ventricles and miliary tubercles upon the tricuspid valve.

The pericardium is somewhat more frequently involved, but even this is an uncommon lesion in childhood. A few gray tubercles are often seen upon its visceral surface in miliary tuberculosis. A diffuse serofibrinous pericarditis may result from the extension of a process in the mediastinal lymph nodes. The condition is seldom recognized during life. It may heal with extensive fibrous adhesions. Most of these





FIG. 172.—TUBERCULOUS PERICARDITIS.

Child eighteen months old with extensive tuberculous lesions in the lung and elsewhere in the body. Death from pneumococcus sepsis. Physical examination during life had revealed only some increase of cardiac dulness and a systolic murmur.

cases are seen in children over two years old. However, we once saw complete obliteration of the pericardial sac from tuberculous inflammation in an infant of eleven months.

#### V. ABDOMINAL TUBERCULOSIS

**Tuberculosis of the Intestines and Mesenteric Lymph Nodes.**—These two conditions are usually associated. Involvement of the mesenteric nodes (*tuberculosis mesenterica*) sometimes occurs, however, when there is no evidence of intestinal tuberculosis. Apparently tubercle bacilli can pass through the intestinal wall without producing a lesion.

Lesions of the intestines and mesenteric nodes are not uncommon in young children. In a series of 386 autopsies at the Babies' Hospital upon tuberculous cases intestinal lesions were found in 40 per cent and mesenteric lymph node lesions in about 60 per cent. Most of these lesions were of minor importance, but in approximately 10 per cent of these cases the oldest lesions were apparently those in the mesenteric nodes.



While it is no doubt possible for infection of the mesenteric nodes to occur through the general circulation, this is exceptional. Infection usually takes place from the intestines; these are examples of tuberculosis by ingestion rather than by inhalation. The bacilli in the intestinal tract may be derived from food, or from sputum which has been coughed up and swallowed. Primary intestinal tuberculosis is rarely found under three years of age. In this country it is now relatively infrequent. In former years most cases were due to the bovine bacillus; with the general improvement in the milk supply the incidence has greatly decreased.

The intestinal lesions most often found in infants and young children are mild in character and are usually associated with and secondary to an advanced pulmonary lesion. They are doubtless due to swallowing tuberculous sputum. In such cases the human type of bacillus is found.

*Pathology.*—INTESTINES.—The usual seat is the small intestine, chiefly the jejunum and lower ileum. With extensive disease the large intestine may also be involved, most frequently the cecum, and exceptionally it alone may be affected. Tuberculous ulcers may be found in the appendix.

The early lesions appear as tiny yellow tubercles, not numerous but widely scattered and generally affecting Peyer's patches. Usually, however, ulcers are present, and often only ulcers are seen. Their size and number vary greatly; there may be only five or six tiny ulcers, or there may be forty or fifty, the largest being two or three inches in diameter. They frequently involve Peyer's patches. The typical tuberculous ulcer is of irregular shape, with rounded borders and with its longest diameter at right angles to the intestinal axis. When large, it may nearly encircle the gut. The ulcers are excavated; they have overhanging, infiltrated edges of a deep-red color. The surface is covered with granulations. Perforation may occur, but rarely into the general peritoneal cavity, as a localized plastic inflammation precedes it. There may be adhesions of adjacent intestinal coils, and fistulae may form, owing to ulceration at the point of contact.

With these severe cases there is always associated more or less extensive tuberculous peritonitis, frequently of the exudative variety. Like other tuberculous processes, the infiltration and ulceration may cease at any stage, and cicatrization follow. If the ulcers have been large ones, there is always some narrowing of the lumen of the intestine. Stricture is rarely seen because most of the children die from the general disease before it has had time to occur. It has been reported as early as twenty-one months. One case has come under our observation in a child of nine years, in which the obstruction was in the colon, just beyond the ileocecal valve.

MESENTERIC LYMPH NODES.—Usually these tuberculous lymph nodes are from half an inch to an inch in diameter; occasionally they may reach the size of a hen's egg. From a fusion of several of them, tumors of considerable size may be formed. We have seen several such masses as large as a man's fist.

The process is the same as that which occurs in other lymph nodes of the body. There is a tuberculous inflammation, followed by caseation, softening and abscess formation, or by calcification. Localized peritonitis is found in all the marked cases; this is usually plastic, but may be suppurative when due to the rupture of an abscess. Pressure upon the vena cava may lead to edema of the lower extremities,



and occasionally thrombosis of the vena cava occurs. Pressure upon the portal vein may lead to ascites and dilatation of the superficial abdominal veins. There may be pressure upon the thoracic duct, giving rise to chylous ascites.

*Symptoms.*—Tuberculous mesenteric lymph nodes may give no symptoms at all. Calcified shadows (Fig. 173) may be detected years later in x-rays taken for some other purpose. Occasionally these nodes may give rise to fever, local tenderness, rigidity and pain, sufficient to lead to exploratory laparotomy.

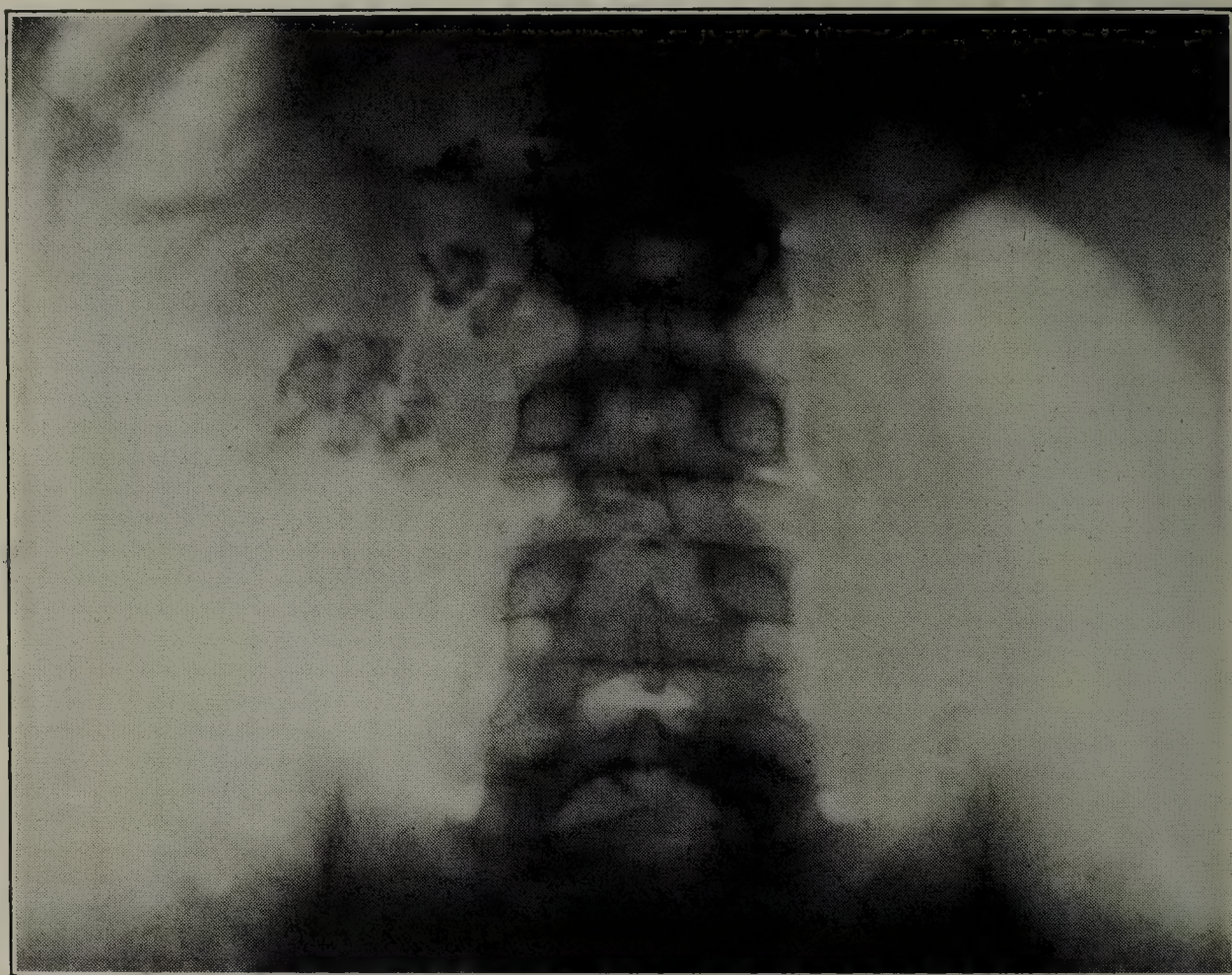


FIG. 173.—CALCIFIED ABDOMINAL LYMPH NODES.

Symptoms of intestinal tuberculosis are exceedingly irregular. Ulcers are very frequently found at autopsy when there have been no intestinal symptoms; this is especially true of the small ulcers seen in infants. When intestinal lesions are more advanced there is usually diarrhea associated with constitutional symptoms. The stools may resemble those of dysentery. An obstinate diarrhea in a child known to be tuberculous should arouse one's suspicion. On the other hand, diarrhea is not uncommon in cases of active tuberculosis elsewhere without involvement of the intestines.

Gross hemorrhages are not very frequent in young subjects, but we have seen a fatal one coming from a single ulcer of the ileum in a nine months' infant. The blood may be fresh or changed. Occult blood is a somewhat more frequent finding. Localized abdominal pain and tenderness are sometimes present; there may be colicky pain. In advanced cases the symptoms are mingled with those of tuberculous peritonitis and there are usually palpable enlarged mesenteric nodes as well. Tuberculous tumors should not be confused with fecal masses; the latter are more freely movable and can be removed by enema or a cathartic. The tuberculous masses generally lie close to the spine; they may be tender. Tuberculous



masses in the intestine or mesentery may be somewhat movable and may be superficial or deep.

There is no relation between the extent of the tuberculous process in the intestine and that in the lungs or elsewhere. There may be myriads of small ulcers in the intestine and yet an x-ray of the chest may fail to show evidence of involvement of the lungs or mediastinal nodes.

*Diagnosis.*—Intestinal tuberculosis with diarrhea must be distinguished from dysentery; it is more insidious and more chronic. Sometimes a severe hemorrhage appears without preceding symptoms and may be confounded with other causes of intestinal bleeding—purpura, intussusception, intestinal polyp, a persistent Meckel's diverticulum, etc. In other instances fever and local pain may cause confusion with other forms of acute abdominal disease. The discovery of tubercle bacilli in the stools does not mean that intestinal tuberculosis is present.

Roentgen-ray studies in adults have shown hypermotility of the intestine in early cases of intestinal involvement. This test has been little used in children. The wide variations in motility in normal subjects impair its usefulness. In advanced cases the picture may be indistinguishable from chronic ulcerative colitis.

With advanced intestinal tuberculosis the outlook is usually unfavorable. The treatment is purely symptomatic. Resection of tuberculous lesions is almost never practicable.

**Tuberculosis of the Peritoneum.**—In early infancy the peritoneum is not often involved even in disseminated tuberculosis, and it is rare for it to be the site of the principal tuberculous process. We have, however, seen extensive peritoneal tuberculosis with ascites in an infant of seven months.

After the first year tuberculous peritonitis is somewhat more common. Of 100 cases observed by Still the largest number were in the second year of life. In 255 autopsies on tuberculous patients, mostly under three years old, at the Babies' Hospital, the peritoneum was involved in 8.6 per cent, but in most of these the lesion was an unimportant one and not the cause of death.

The bovine bacillus is responsible for many of these cases. Tuberculous peritonitis is more frequent in Europe, where infections with this organism are still common. In this country public health measures aimed at the suppression of bovine tuberculosis have cut down the incidence of these infections in recent years.

In acute miliary tuberculosis, tubercles may be scattered rather sparsely over the peritoneum. The evidences of inflammation are slight and there are no local symptoms. In these cases the infection is blood-borne. The great majority of instances of outspoken peritonitis, however, appear to result from alimentary infection. Tuberculous peritonitis is usually associated with lesions in the intestines, though these may not be conspicuous. Sometimes these intestinal lesions are not demonstrable, indicating that the infection has passed through the intestinal wall without leaving a trace.

Two varieties of tuberculous peritonitis are generally distinguished: the ascitic and the plastic form. Mixed varieties may occur.

*Ascitic Form.*—This is much the less frequent of the two. The peritoneum is more or less thickly sown with miliary tubercles, both discrete and in conglomerate masses. They are found in the omentum and mesentery and upon the surface of



the intestines and other viscera. Sometimes a cluster or ringed grouping of tubercles on the serous surface of a loop of intestine shows where direct extension from an intestinal ulcer has occurred. At other times there is evidence of spread from the pleura through the diaphragm, from a caseous lesion in a mesenteric lymph node, or rarely from some other structure. The peritoneal surface may be smooth and glistening, or may be roughened with fibrinous exudate or delicate granulations. In the more acute cases the fluid is in the general peritoneal cavity; in those of longer duration it may be sacculated. It is usually straw-colored serum, but may be seropurulent, or even bloody. As a rule it contains few organisms. In the average case the associated tuberculous lesions in other parts of the body tend to be mild.

Clinically, ascitic cases usually present the symptoms of a low grade of peritoneal inflammation. The onset is gradual, with indefinite general symptoms. There is frequently some fever— $100^{\circ}$  to  $101^{\circ}$  F.; but there may for a long time be none. In the majority of cases there is a slowly developing ascites without any inflammatory signs, abdominal enlargement being practically the only symptom. In others there is weakness and loss of weight, rarely prostration and emaciation. Vomiting is not prominent; when it occurs it is likely to result from mechanical obstruction, associated with the formation of adhesions, and to denote a mixed ascitic-plastic form of the disease. Pain and tenderness seldom occur in the pure ascitic form; severe diarrhea suggests a complicating tuberculous enteritis.

The ascitic form of the disease may result fatally by slow extension of the disease or from generalized tuberculosis. At other times the fluid may be gradually absorbed and recovery take place. After absorption the plastic form may develop.

*Plastic Form.*—This is generally slower in its development and more chronic in its course than the ascitic form. The important feature is the production of extensive organized adhesions between the solid viscera and the intestines, among the intestinal coils, and between the intestines and the abdominal walls. On opening the abdomen at autopsy, the entire contents are sometimes seen to be fused together into one solid mass which looks as if plaster of paris had been poured in and had set.

These adhesions and their mechanical consequences are sometimes almost the only lesions present. In other cases there may be an accumulation of fluid, which may be sacculated or in the general peritoneal cavity. This may be serous, seropurulent, or purulent. The omentum is often rolled up into a thick mass occupying the epigastrium and extending transversely across the abdomen. Scattered through the fibrous adhesions, in the mesentery, or in the omentum, there are generally numerous caseous nodules, some of which attain considerable size and undergo softening. Tuberculous involvement of the intestinal walls may lead to perforation, and sometimes to fistulous communications between adherent coils. There may also be tuberculous infiltration of the abdominal wall, causing cellulitis or the formation of abscesses, which may open externally, usually in the neighborhood of the umbilicus.

The onset is generally insidious, and fever is slight and often absent. There is rarely vomiting in the early stages. The bowels may be constipated or loose. In



some cases the process is entirely latent and is discovered at autopsy when there have been no abdominal symptoms during life. Many patients show some enlargement of the abdomen or irregularity in the abdominal contour due to tympanites or to small accumulations of fluid. The most significant physical sign is a demonstrable roll of omentum in the epigastrium. This may be as wide as a man's hand, and the irregular lower border is usually distinct by palpation; less often the upper border also. It may be mistaken for an enlarged liver. Frequently one detects a doughiness or peculiar loss of elasticity on palpation of the abdomen which, while not in itself specific, acquires great importance when combined with other evidence of tuberculosis.

Clinically, these cases are distinguished by their slow, irregular course. They are the most chronic of all the forms. Ascites may develop slowly, but is rarely abundant and may disappear spontaneously. Other symptoms may appear, depending upon the mechanical effects of pressure from the contracting adhesions. There may be more or less constriction of the intestine, pressure upon the vena cava, the renal or portal veins, the thoracic duct or its branches, or upon the stomach. These conditions may give rise to dyspeptic symptoms, emaciation, edema of the lower extremities, and albuminuria.

If softening and breaking down of inflammatory products take place, constitutional symptoms are usually present. The temperature ranges from 99° to 102° F., occasionally much higher. There is progressive wasting, anemia, prostration, and sometimes sweating. Diarrhea is frequent and the intestinal discharges may at times be bloody. The abdomen is large, but not so much distended as in some of the other forms; the superficial veins are frequently prominent. Ascites often cannot be made out by percussion, even though fluid is present. Areas of dullness and tympanitic resonance are irregularly distributed. Nodular masses of various sizes and irregular shapes may be felt anywhere in the abdomen, but they are more frequent in the region of the umbilicus and in the right iliac fossa than elsewhere. The thickened omentum may be mistaken for an enlarged liver. There may be the signs of phlegmonous inflammation of the abdominal wall in the neighborhood of the umbilicus, and even an abscess, which, after opening, may leave a fistulous tract communicating with the peritoneum. There are in many cases signs of disease in the lungs, and the pulmonary symptoms may mask those of the abdomen. The course of the disease, when softening and breaking down have taken place, is steadily progressive, the usual duration being from three to six months. Death results from the pulmonary disease, from tuberculous meningitis, from cachexia, occasionally from ileus or intestinal perforation.

*Diagnosis.*—A positive tuberculin reaction is always present. In the ascitic form there may be insignificant systemic symptoms, but with physical signs of tuberculosis elsewhere the diagnosis is almost certain. In young children chronic ascites without anasarca usually means tuberculous peritonitis. In older children the ascites that sometimes accompanies adherent pericardium must be borne in mind. Cirrhosis of the liver is rare in infancy and early childhood. Pouting of the navel, with induration and redness about it, is suggestive and any chronic abscess in the neighborhood of the umbilicus should arouse suspicion. If the abdominal effusion is sacculated instead of diffuse, the probabilities of tuberculous



peritonitis are much increased. Exceptionally a pneumococcus or streptococcus peritonitis may develop so insidiously and be so free from the usual local pain and tenderness that, when associated with a positive tuberculin test dependent on a focus in some other part of the body, the differentiation is impossible without examination of the fluid. Distention of the bowel in celiac disease or in Hirschsprung's disease is sometimes mistaken for ascites.

The plastic form is more likely to be accompanied by wasting, colicky pains, irregularity of the bowels, anorexia, and usually slight but continuous fever. Irregular nodules or masses in various parts of the abdomen, not removable by cathartics or enemata, lend weight to the diagnosis, and the broad epigastric tumor formed by the matted omentum is especially significant. In other cases one finds only the doughy consistency above referred to. Fever may not be observed for a long time, even though local symptoms are marked. The blood count is not very helpful.

Abdominal paracentesis, even in the presence of a generalized peritoneal effusion, is not without risk owing to the possibility of adherence of intestinal coils at the site of puncture. In the plastic form it is definitely contraindicated.

*Prognosis.*—Tuberculous peritonitis is always a serious disease, but by no means a hopeless one. The younger the child, as a rule, the more rapid the progress of the disease and the worse the outlook. The prognosis is especially bad during the first two years of life; at this period probably the majority of the cases terminate fatally. Many cases occurring in older children recover spontaneously and entirely. The most hopeful ones are those with ascites. But even in the plastic form some apparently complete recoveries take place, the adhesions disappearing by absorption to a degree truly remarkable. The most unfavorable cases are those in which there is strong evidence of breaking down of the lesions and dissemination of the disease, with continuous fever, wasting, and leukocytosis.

*Treatment.*—Most of these cases respond to general measures alone, particularly heliotherapy. Operative treatment, once popular, is being resorted to less and less. Occasionally it may be necessary in the presence of obstructive symptoms, but there is little prospect of permanent relief and the operation may have unfavorable immediate consequences. The intestine may be injured in breaking up adhesions and fecal fistulae not uncommonly follow.

**Tuberculosis of Other Abdominal Viscera.**—Any of the organs are likely to show miliary tubercles in cases of miliary tuberculosis, but lesions extensive enough to produce symptoms are most exceptional. E. A. Park has reported an instance of a young infant who developed obstructive jaundice as the result of numerous tubercles surrounding and filling the finer bile ducts.

## VI. TUBERCULOSIS OF THE URINARY TRACT

In generalized tuberculosis, miliary tubercles are frequently seen both upon the surface of the kidney and in its substance. These give rise to no symptoms. Large areas of tuberculous involvement in the kidney are exceedingly rare in early life, whether as solitary foci or as part of more extensive involvement of the urinary tract. There is usually extensive tuberculosis in other organs, but renal tuberculosis



may exist as the only important lesion in the body. Nearly all such cases result from blood-stream dissemination of organisms; ascending infection is almost unknown. Aldibert's figures show that in children the bladder usually escapes even when the kidneys contain caseous lesions, for of 13 cases of renal tuberculosis the bladder was involved in but 2. As a rule but one kidney is affected.

The process may begin in the cortex or in the pyramids, and in time is likely to spread and to form caseous abscesses involving practically the entire parenchyma, so that in advanced cases the kidney consists of a mere shell of renal tissue. Perinephric abscess sometimes coexists.

The symptoms are indefinite, and usually of mild degree in comparison with the destruction present. There may be localized pain and tenderness in the region of the kidney, and a tumor if there is pyonephrosis or perinephritis. Bladder symptoms, when present, may be almost as severe as in cases of calculus. Pus usually appears in the urine as a constant symptom and blood is often present. The diagnosis is established by the discovery of tubercle bacilli in the urine, or of tubercles at the ureteral orifice by cystoscopy.

The treatment is the same as in adults.

## VII. TUBERCULOSIS OF THE SKIN

Primary tubercle of the skin is exceedingly rare, except in cases of cutaneous vaccination with B.C.G. There have been several instances of tuberculosis of the penis in connection with ritual circumcision due to gross errors in hygiene; most of these patients have succumbed to a rapidly progressive generalized infection.

The two important forms of tuberculosis of the skin in childhood are the so-called *papulonecrotic tuberculids* (acne scrofulosorum) and *lichen scrofulosorum*. Both are due to hematogenous dissemination of tubercle bacilli.

The papulonecrotic tuberculid seen in children is a small red papule of miliary size which is soon surmounted by a vesicle. This dries to form a crust. If the crust is removed a small pit-like depression remains which heals quickly. If left alone the lesion retrogresses and tends to become brownish, and the crust drops off. There is finally left a white central pit-like depression surrounded by a pigmented border. The lesion runs its entire course in two or three weeks. Anatomically it is a miliary tubercle, and bacilli have been demonstrated both in sections and in scrapings. The lesions may appear in crops; sometimes they are very numerous, but more often only a few are present, perhaps only half a dozen. They are more commonly found on the buttocks, lower abdomen, genitalia and thighs, but may be found in any part of the body. They are not symmetrically distributed and may appear in unusual locations, such as the concha of the ear.

These tuberculids are of considerable diagnostic value, for their occurrence indicates that hematogenous dissemination is taking place. Their presence is an unfavorable prognostic sign, and such patients rarely survive more than a few weeks. We have, however, seen two children between two and three years of age who had repeated crops of tuberculids, with pulmonary signs of disease, who recovered and have remained well for more than five years.

Larger tuberculids, such as occur in adults, are rarely met with in children. We have seen them occasionally. When they heal definite scarring remains.



*Lichen scrofulosorum*, less conspicuous than papulonecrotic tuberculids, is also more rare. It consists of fine, rounded or flattened papules, slightly redder or darker than the surrounding skin, covered with an indistinct scale, and grouped closely together in rounded or oval clusters about the size of the terminal phalanx of one's finger. These clusters, of which there may be few or many, are generally found on the trunk, especially on the back or over the abdomen, but may also occur on the shoulders and thighs. In appearance and distribution they may resemble pityriasis rosea. The tuberculous nature of lichen scrofulosorum is attested by its association with active evidences of the disease elsewhere, by its histologic structure, by its aggravation following subcutaneous injection of tuberculin, and by the recovery of organisms, the last admittedly rare. It is of no particular value in prognosis.

Papulonecrotic tuberculids and lichen scrofulosorum, both of which are dry lesions, inconspicuous to view and unaccompanied by subjective symptoms, are seldom noticed by the patient or by parents. The frankly ulcerative and occasionally painful forms of secondary cutaneous tuberculosis—lupus vulgaris, scrofuloderma, and certain types of ulcers about the mouth and anus—are described in textbooks of dermatology.

#### VIII. TUBERCULOSIS OF THE BONES AND JOINTS

All that will be attempted in this chapter will be to outline in a general way the most important forms of tuberculous bone disease, dwelling particularly upon the early symptoms and diagnosis. For their fuller discussion, particularly as to the details of treatment, the reader is referred to textbooks on general or orthopedic surgery. The causes are the same, and the lesions are very similar in all forms, and will therefore be considered together.

**Etiology.**—Of 71 cases in children investigated by Park and Krumwiede, or collected by them, the bacillus was of the human type in 68 and bovine in but 3 instances. Bone tuberculosis due to the bovine bacillus is, however, more common in Scotland and certain other countries. The age at which tuberculosis of the bones most frequently begins is from the third to the eighth year, it being comparatively rare before the end of the second year. It may occur in a child who has previously been in apparent health, but more often in one who has been reduced by some previous illness, especially one of the infectious diseases. Of these, it most frequently follows measles and whooping cough. Traumatism is often an exciting cause, and it may determine the site of the disease.

**Pathology.**—The tuberculous joint diseases of childhood are secondary to disease of the bones, usually of an epiphysis. Tuberculosis of the hip joint usually begins in the head of the femur, of the knee joint in one of the condyles, of the ankle joint in the lower epiphysis of the tibia.

The frequency with which disease is seen in the different locations is indicated by the following table, which gives the number of cases of each form applying for treatment at the Hospital for Ruptured and Crippled, New York, during twenty years.



TABLE LVII

	Cases	Per Cent
Spine .....	4,299	39.6
Hip .....	3,329	30.7
All other joints .....	3,222	29.7
TOTAL .....	10,850	100.0

In the long bones the process usually begins near the epiphyseal line; in the short bones it is apparently a central osteitis. The stages in the process are congestion, swelling, and cell infiltration, followed by caseation, and frequently by softening and suppuration. In the early stage, the bone is slightly enlarged, and on section one or more yellowish foci of disease are seen. The disease may be arrested in this stage, encapsulation of the inflammatory products taking place; or it may continue until there is a more or less extensive breaking down or disintegration of the affected bone. As the disease extends there are involved the periosteum, the articular cartilage, and finally the joint itself. Abscesses may form in the joint or in the soft parts surrounding the bone. The process is quite analogous to tuberculous disease of the lung. As the disease advances ligamentous attachments are loosened, and displacement of the parts occurs with the production of deformity, due partly to muscular contraction and partly to the weight of the body. The inflammatory process with its resulting disintegration generally goes on to a certain point, where it is arrested. Gradually the broken-down bone substance is separated and thrown off in small particles in the discharge, and a reparative process begins with the formation of healthy bone. Where joint structures have been destroyed, cure takes place by bony ankylosis. Sometimes the disease finds its way to the surface without involving the joint; at other times the disease may be arrested, and the process become encapsulated within the bone. Inflammation of the joint may occur by a gradual extension of the inflammatory process, or by a sudden perforation of the articular lamella. As a result of extensive disease, all the joint structures may be affected—the synovial membrane, ligaments, articular cartilages, and the cellular tissue surrounding the joint. The process of disintegration and that of repair are both very chronic and measured by months or years. The entire course of the disease is from one to ten years, three years being about the average duration. In the great proportion of cases but one joint is involved, although it is not infrequent in hospitals to see two, three, and sometimes four of the large joints affected in the same patient.

Abscesses form in a considerable proportion of the cases, and often burrow a long distance before they reach the surface. Amyloid degeneration of the liver, spleen, and kidney, and sometimes of the intestines, occurs as the result of the prolonged suppuration, chiefly in connection with disease of the hip or spine, occasionally with that of the knee. General or localized tuberculosis, particularly tuberculous meningitis, may develop at any time and prove fatal.



*Tuberculous Caries of the Spine—Pott's Disease*

This consists in a tuberculous inflammation of the bodies of the vertebrae, usually beginning in the central portion and extending to the periosteum, ligaments, intervertebral disks, and, in fact, to all the contiguous structures. Secondly it involves the membranes of the cord, the roots of the spinal nerves, and even the cord itself. The number of vertebrae usually affected is from two to five. After the bodies of the vertebrae have become softened and partially broken down by disease, the pressure from the superincumbent weight of the body causes them to fall together and produces a backward displacement of the spinous processes, giving rise to the deformity known as kyphosis, which in its extreme form is popularly known as "hunchback."

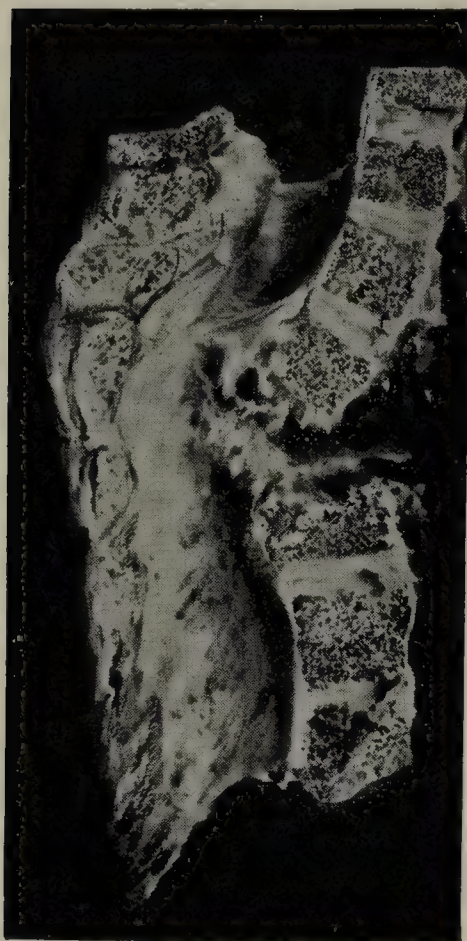


FIG. 174.—POTT'S DISEASE OF THE UPPER DORSAL REGION.

A vertical section of the spine, showing disintegration of the bodies of the vertebrae and encroachment upon the spinal canal (from a patient dying in the Hospital for Ruptured and Crippled).

Any part of the vertebral column may be affected, but the disease is much more frequent in the dorsal region, as shown by the following statistics from the Hospital for Ruptured and Crippled: Of 2143 cases, 72.5 per cent affected the dorsal region, 15.3 per cent the lumbar region, and 12.2 per cent the cervical region.

Whitman gives the following statistics for the age of onset in 1259 cases:

<i>Age</i>	<i>Per Cent</i>
Less than 1 year.....	3.1
1 and 2 years.....	14.2
3 to 5 years.....	50.2
6 to 10 years.....	18.3
Over 10 years.....	14.2
	<hr/> 100.0

*Symptoms.*—The onset is gradual, often insidious, and the early symptoms are frequently overlooked or misinterpreted. The case may go on for weeks or even months before the true nature of the disease is recognized, which is often not until deformity has occurred. In nearly all cases, however, the early symptoms are sufficiently characteristic to enable a careful observer to make a diagnosis before the stage of deformity.

The most constant early symptoms are: (1) pains caused by the irritation of the nerve roots and referred to various parts of the body, following the distribution of the spinal nerves; (2) rigidity of the spine from muscular spasm, this being an attempt to prevent motion at the seat of disease; and (3) the assumption of various postures calculated to relieve pressure upon the diseased vertebral bodies. Sometimes the first symptoms are those of pressure-paralysis; at others they are the local signs of abscess. In addition to the local symptoms mentioned, there is usually disturbed sleep, often accompanied by moaning.



**CERVICAL POTT'S DISEASE.**—The pains are often felt above the point of disease, frequently in the form of occipital neuralgia; sometimes they are referred to the front or the side of the neck. They may be so frequent and so severe that the face assumes a constant expression of anxiety or distress. In other cases pain is excited only by an attempt at movement. The muscular spasm most frequently takes the form of slight torticollis, sometimes of slight opisthotonos; sometimes there is simply a fixation of the head by a tonic spasm of all the muscles of the neck; both

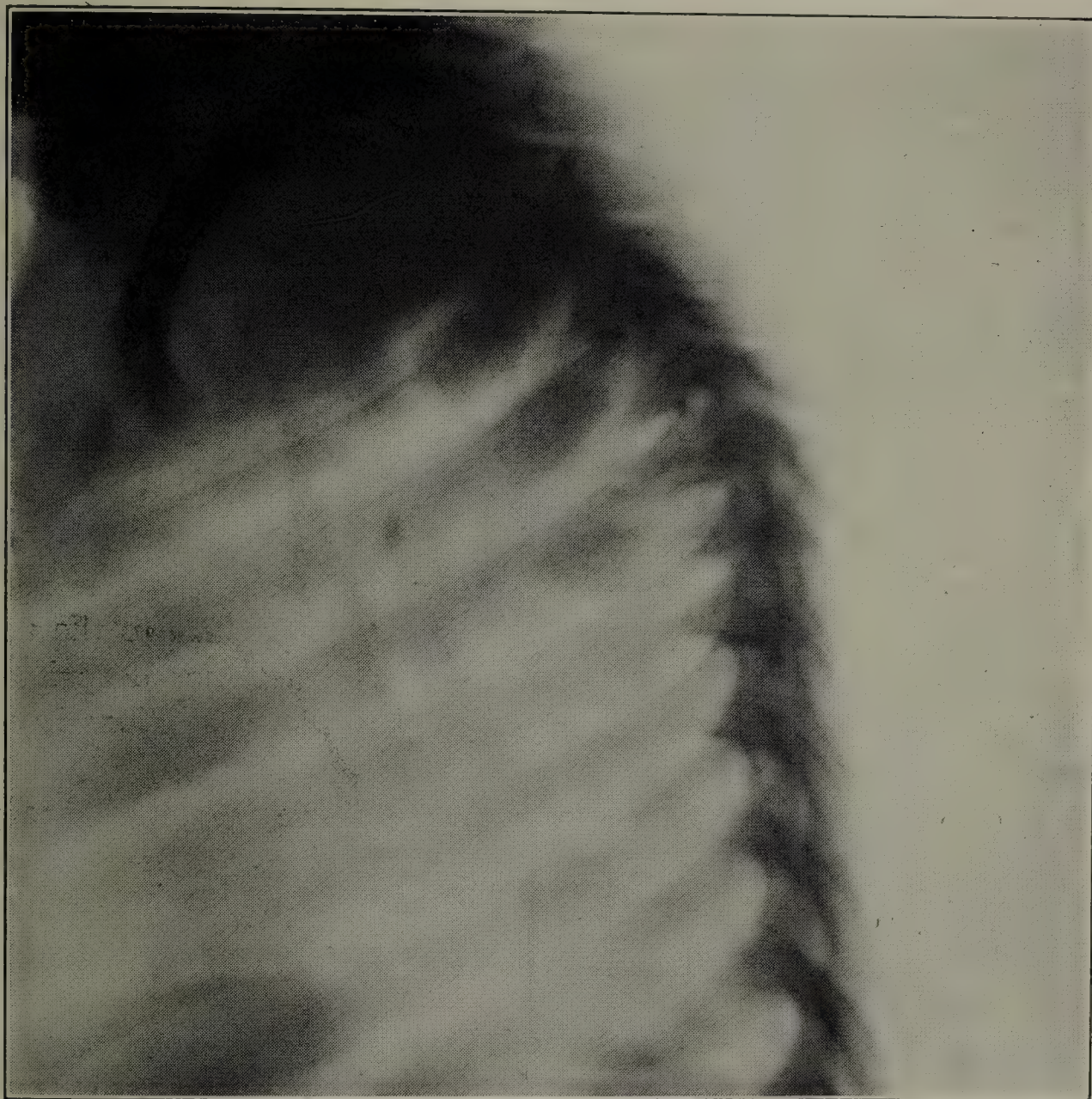


FIG. 175.—ROENTGENOGRAM IN TUBERCULOSIS OF SPINE, SHOWING COMPLETE COLLAPSE OF ONE VERTEBRAL BODY AND PARTIAL COLLAPSE OF ANOTHER, WITH ACUTE ANGULATION.

active and passive motion is resisted, and any movement may be so painful that the child involuntarily steadies his head with his hands. These symptoms come on gradually and are persistent. Sometimes they are overlooked, and the first thing to attract attention is a progressive weakness in the lower extremities, which proves to be the beginning of paraplegia. Occasionally the first marked symptoms are those due to the formation of a retropharyngeal or a retro-esophageal abscess.

The deformity from cervical disease develops much later than when the disease is located elsewhere. Usually the neck appears broadened or thickened in a nearly uniform way, and often the head seems to have settled downward upon the shoulders. In the lower cervical region a kyphosis is not infrequent; but in the



middle and upper regions there is more often an anterior prominence, which may be felt in the posterior wall of the pharynx.

**DORSAL INVOLVEMENT.**—The referred pains are now below the seat of disease, and take the form of intercostal neuralgia or pain in the epigastrium or the abdomen. There is a disposition to assume the prone position while sleeping, and also to lean across a chair or the lap of the nurse. The child walks carefully, holding the spine erect and very stiff, and exhibits great caution in getting into or out of bed, or in rising from a recumbent position. In the beginning there may be a slight lordosis, or forward curve at the seat of disease, instead of the usual kyphosis or backward projection, but the latter soon takes its place, and with it is seen the compensatory lordosis in the lumbar region.

**LUMBAR INVOLVEMENT.**—The first symptoms here are often pain and lameness, referred to one of the lower extremities. This frequently leads to the suspicion that the hip is the seat of disease. In addition to the lameness there may be a tilting of the pelvis to one side, and sometimes quite a distinct lateral curvature of the spine. Referred pains are not so frequent nor so severe as when the upper part of the spine is affected; they may be felt in the groin, in the loin, in the thigh, in the buttock, or in the hypogastrium. The gait and attitude are very characteristic: throwing the shoulders well back, the patient walks stiffly, with short steps, holding the spine with the greatest care. He rises from the floor awkwardly and with difficulty. Deformity is not usually so early nor so marked as when the disease is dorsal, and often before it is visible there are symptoms due to the formation of psoas abscess—lameness, flexion of one thigh, and a tumor deep in the iliac fossa or at the upper and inner aspect of the thigh; in both locations it has often been mistaken for hernia.

*Physical Examination.*—Whenever any of the above symptoms are present, the child should be stripped and submitted to a thorough examination, the purpose of which should be to determine, first, the existence of any deformity; secondly, the mobility of the spine; thirdly, the presence of any secondary lesions, such as abscesses or paralysis. Spasm of the spine is best determined by tests of passive mobility and by studying the attitude, gait, and posture of the child, and the manner of stooping or rising from the floor. The gait has already been described with the symptoms of lumbar disease. As it has been aptly put, "the child walks with his legs, but not with his back." In stooping, the same disinclination to bend or move the spine is seen. It is often impossible to induce the child to stoop at all, and when he does so to pick up some object, there is acute flexion at the knee and hip, but as little bending of the spine as possible. In rising from the recumbent position the same thing is seen. The posture and attitude of the child will be modified by the position of the disease, and somewhat by the activity of the process at the time; however, by comparing the movements referred to with those of a healthy child, the great difference will at once be apparent. If the symptoms point to cervical involvement, a digital exploration of the pharynx for deformity or abscess should be made, and the extremities should be examined for paralysis. If the disease is in the lumbar region, deep palpation of the iliac fossa should be made to discover a psoas abscess, and the passive movements of the thigh should be carefully tested to determine whether there is any resistance to extreme extension, this



often being present before the psoas tumor. No matter how clearly the lameness may be at the hip, it should be remembered that this often results from disease of the lumbar spine. If the thigh is flexed and freely movable except in extension, the symptoms are probably the result of psoas irritation, for in tuberculosis of the hip the other movements of the joint are also resisted.

The deformity of Pott's disease is often spoken of as "angular" curvature of the spine. While this is a true description of the disease at an advanced stage, there is often in the early stage only a general curve. Later a slight knuckle is seen from the unnatural projection of a single spinous process. This deformity



FIG. 176.—COLLAPSE OF AN INTERVERTEBRAL DISK, THE EARLIEST X-RAY SIGN OF TUBERCULOSIS OF THE SPINE.

may increase and finally involve five or six vertebrae. It is usually greatest in the upper dorsal region. A slight prominence, which does not disappear on suspending the patient, is always suggestive.

Tenderness upon pressure over the spinous processes is rarely present. Pain may sometimes be produced by downward pressure upon the head or shoulders in the axis of the spine. This symptom is not necessary for diagnosis, and the attempt to elicit it should be condemned.

An exaggeration of tendon reflexes below the level of the kyphos is commonly found as an early symptom of pressure on the spinal cord. With increasing deformity paralysis may appear (see Myelitis), usually in cases with upper dorsal caries.

*Course of the Disease.*—Caries of the spine is a very chronic disease, its course being measured by months or years, marked by periods of remission and exacerbation. An exacerbation may follow traumatism, and is often accompanied by the formation of an abscess. After the disease has lasted from one to three years,



the destructive inflammation usually ceases and repair begins, a cure being finally effected by fusion of the fragments of the diseased vertebrae, with the production of ankylosis. Relapses are easily excited by traumatism, by improper treatment, or by discontinuing mechanical supports before the disease is arrested.

*Abscesses.*—There are rarely seen earlier than three or four months from the beginning of the symptoms, and usually belong to the second year of the disease. They sometimes form with acute symptoms, but more frequently they appear as typical cold abscesses. Those connected with cervical disease are retropharyngeal or retro-esophageal, or they may open externally, usually just above the clavicle, in

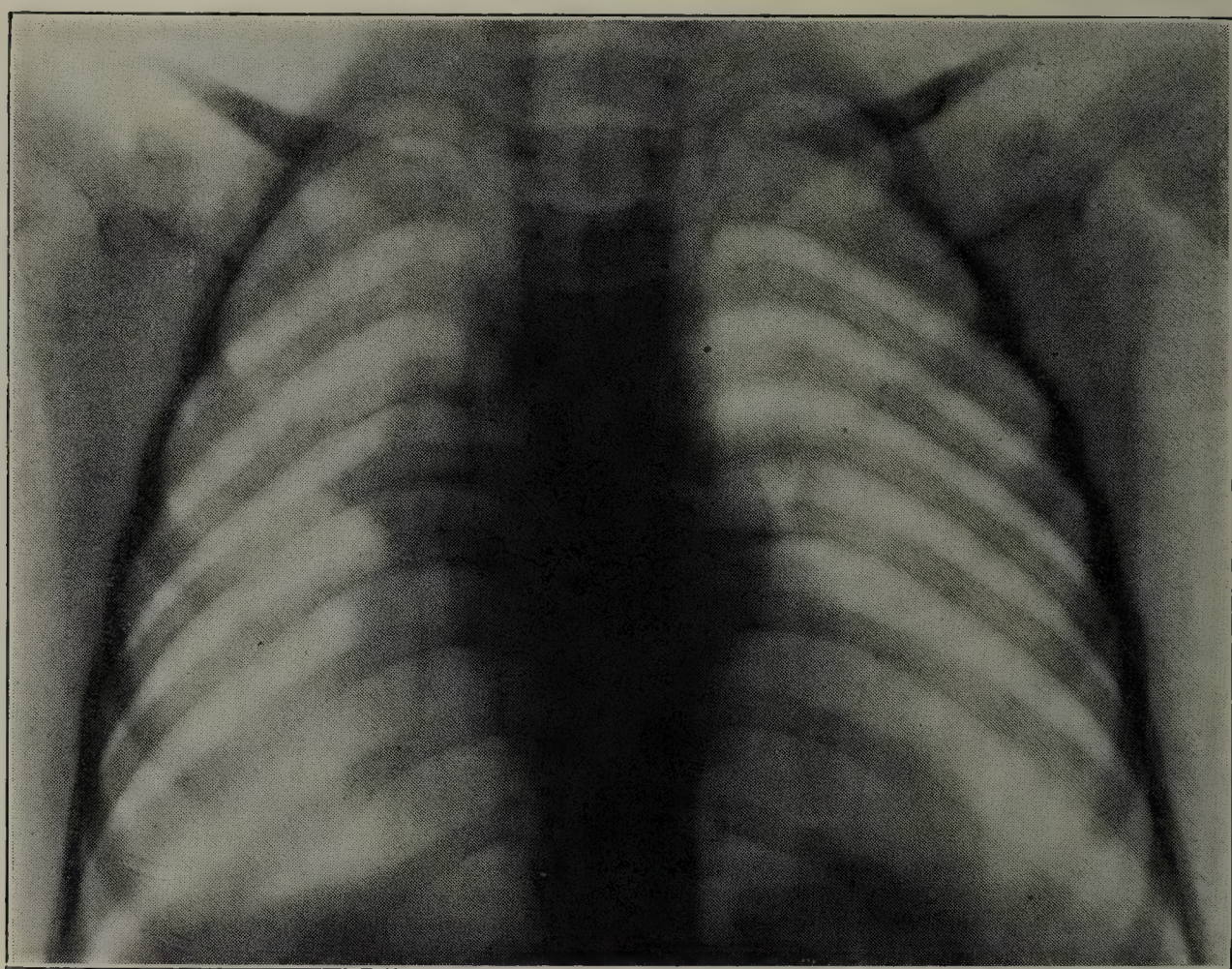


FIG. 177.—PARAVERTEBRAL ABSCESS FROM TUBERCULOUS CARIES OF THE SPINE.

front of the sternomastoid muscle. Those with disease of the lower cervical and upper dorsal vertebrae are apt to burrow along the spine, appearing in the lumbar region; rarely they may rupture into the esophagus or the pleural cavity. Those with disease of the lower dorsal or lumbar vertebrae may open just above the iliac crest posteriorly, or burrow between the abdominal muscles; but the usual course is for them to follow the psoas muscle, appearing in the groin just above Poupart's ligament or at the upper and inner aspect of the thigh. In successfully treated cases they may subside without discharging.

Paravertebral abscess may be discovered by x-ray at a relatively early stage. It appears as a fusiform shadow, usually symmetrical on both sides of the spine and of a density intermediate between that of the vertebrae and of soft tissues like the heart. The size which such lesions may attain without giving rise to mechanical symptoms is truly astonishing.

*Prognosis.*—The actual mortality of Pott's disease is difficult to state, so many of the consequences of the disease being remote and not fully appreciated until



adult life is reached. The causes of death are cachexia from prolonged suppuration, amyloid degeneration, myelitis, disseminated tuberculosis, and tuberculous meningitis. Sudden death occasionally occurs from pressure upon the cord in the upper cervical region, or from the pressure effects of abscesses behind the pharynx or in the posterior mediastinum.

The prognosis as to the amount of permanent deformity will depend upon the seat of the disease, the time at which treatment is begun, and upon the thoroughness with which it is carried out. The best results as to deformity are obtained when the disease is below the middle dorsal region. With proper treatment begun early, a large number of these patients recover with an insignificant amount of deformity, and some with none whatever.

*Diagnosis.*—Timely recognition depends on the demonstration of characteristic muscle spasm and on roentgenographic findings—narrowing of the intervertebral disks and, subsequently, destruction of one or more vertebral bodies. Clinically, the spinal deformity resulting from Pott's disease may be confounded with rachitic kyphosis or with rotary lateral curvature. Rachitic curvatures are usually seen in children under eighteen months of age, a time when Pott's disease is rare; other signs of rickets are present, and instead of rigidity there is usually undue mobility of the spine. The same may be said of curvatures depending upon malnutrition.

Other abscesses may be mistaken for those dependent upon vertebral caries. These abscesses are most frequently in the iliac fossa or in the lumbar region, and may be due to perinephritis or appendicitis. The latter are more acute than those depending upon bone disease, and are usually accompanied by fever. Tumors of the vertebrae or of the spinal cord may give rise to symptoms almost identical with those resulting from compression myelitis due to Pott's disease. Both of these are rare.

*Treatment.*—The treatment of Pott's disease is both general and local, and neither should be neglected. The constitutional treatment should be similar to that employed in other forms of tuberculosis. The local treatment belongs to the domain of orthopedic surgery.

### *Tuberculosis of the Hip*

In early childhood this generally begins in the epiphysis of the head of the femur, starting near the epiphyseal line. Exceptionally, and oftener in older children, it begins in the acetabulum. The process is generally described in three stages. In the first—that of osteitis—the lesions are limited to the bone; in the second—that of arthritis—the joint structures are involved, and suppuration usually occurs; in the third stage there is breaking down and absorption of the head and sometimes of the neck of the femur, which, with destruction of the ligaments, leads to marked displacement of the parts from muscular contraction. The disease may be arrested in the first or in the second stage, or it may continue through all three stages.

*Symptoms.*—Clinically, the usual duration of the *first stage* is three or four months; it may last for only a few weeks or may extend over years; the disease may be arrested in this stage. The onset is usually gradual, and the symptoms are often considered of trivial importance until they have continued for some weeks.



Generally the first thing noticed is slight lameness, due to stiffness of the joint. In the beginning this may be seen only in the morning, wearing off during the day. It may be accompanied by some tenderness about the hip and a disinclination to walk. A little later the child complains of pain, which is most frequently referred to the front of the knee or the inner aspect of the thigh, but only in rare cases to the hip

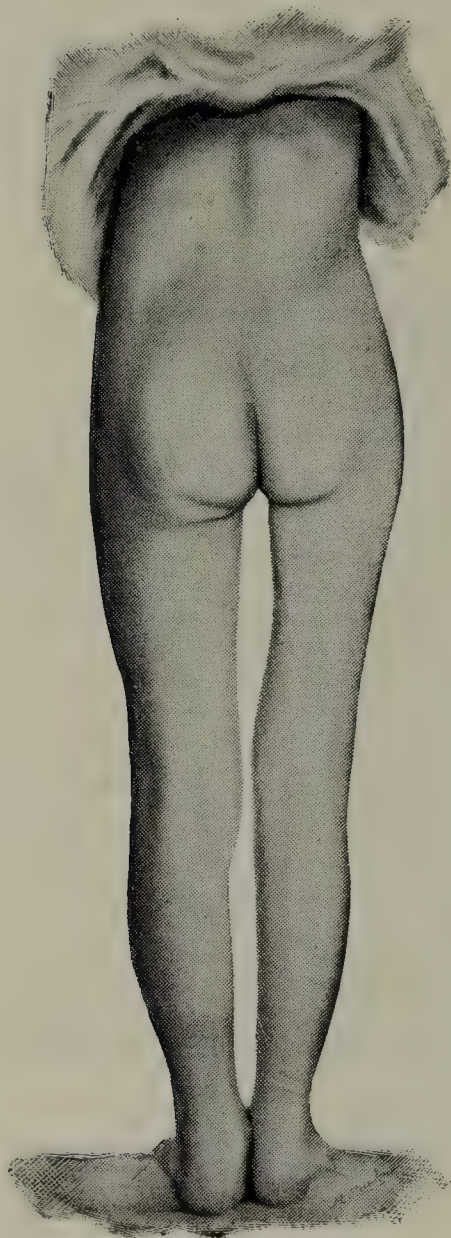


FIG. 178.—HIP-JOINT DISEASE, AT THE END OF THE FIRST STAGE.

Showing muscular atrophy, prominence of the trochanter, flattening of the gluteal region, and a single gluteal fold.

itself. This is slight at first, but gradually increases in frequency and severity. Many patients reach an advanced stage of the disease with little or no pain, yet few escape without starting-pains at night—the “night cry,” which is one of the most characteristic features of tuberculosis of the hip. These pains are produced as the protective muscle spasm, present during the day, is relaxed during sleep. The child often cries out sharply without waking, sometimes wakes with a cry, holding on to the thigh or knee on the affected side; this is often repeated several times during the night. Soon restlessness and fretfulness during the day are present. The lameness, which at first was slight and occasional, comes to be a constant symptom, and week by week increases in severity. These symptoms sometimes come and go for months or even years before they are fully developed.

The first points to be observed on inspection relate to the general contour of the hip; every prominence and depression should be carefully noted. Then the attitude and gait and finally all the functions of the joint should be carefully tested, and the limbs measured, to determine the existence of shortening and especially of atrophy. At every step a comparison should be made with the sound limb. The contour of the hip is changed quite uniformly; there is broadening and flattening of the whole gluteal region; the trochanter is unnaturally prominent; the gluteal fold is shortened, and often single instead of double. There is no characteristic position of the limb in this stage. There is marked atrophy of the thigh and often of the calf. In Figure 178 is shown the appearance of a typical case in the full development of the first stage. In waking, the child favors the diseased side, throwing the weight as much as possible upon the sound limb.

The child should be placed upon a table upon his back, and the various movements of the hip—abduction, adduction, flexion, extension, and rotation—should be executed, first with the sound limb and then with the suspected one, the two being carefully compared at every point to determine the degree of motion allowed. If the symptoms have existed for some weeks, there is generally a limitation of motion at the hip in all directions, but first usually in abduction, rotation, or extension. In more advanced cases, no motion whatever may be permitted at the joint,



the pelvis tilting with the slightest movement of the femur. This fixation of the hip is due to muscular spasm.

**SECOND STAGE.**—This has been called the stage of arthritis. Its existence may be assumed when the limb takes the position of marked permanent deformity, which is due at this period to muscular action, not to destructive bone changes. The transition from the first to the second stage is in most cases a gradual one, and the line between the two cannot be sharply drawn; sometimes, however, it is rapid, and marked by a sharp exacerbation of all the symptoms. This may indicate a sudden perforation of the joint and the rapid development of suppurative arthritis. Such is the usual result when an abscess which has been slowly forming in the bone opens into the joint; or acute joint inflammation may be lighted up without so evident a cause. Sometimes the pus reaches the surface below the capsular ligament, and the joint remains intact. An acute exacerbation is indicated by increased pain, excessive tenderness about the hip, often by inability to walk or even to bear any weight upon the limb, and frequently by fever. The position assumed by the limb is now fairly characteristic. The foot is generally everted, the thigh slightly flexed and rotated outward, and the limb apparently lengthened. There may be infiltration anywhere about the hip, due to the formation of an abscess. The muscle spasm is so great that no motion whatever is allowed. Abscesses may form at any point about the hip; they are especially frequent at the upper and outer aspect of the thigh, and may burrow long distances before reaching the surface. The duration of the second stage also is indefinite, but it usually lasts from a few months to a year.

**THIRD STAGE.**—There is now marked deformity, which is the result of muscular contraction after absorption of the head and sometimes the neck of the femur, and destruction of the ligaments. The position of the limb is a very constant one, and resembles that present in dislocation upon the dorsum of the ilium. There is shortening of from 1 to 4 inches, the thigh is strongly flexed, adducted and rotated inward, and the foot is inverted; the trochanter lies against the outer surface of the ilium, and is above Nélaton's line. In this position the joint may become ankylosed. The displacement usually comes on gradually, but it is sometimes so sudden as to be mistaken for a true dislocation.

There is now marked atrophy of all the muscles of the limb, and the thigh may be two or three inches smaller than its fellow. No motion at all is allowed at the hip, but this is compensated for to some degree by the exaggerated mobility of the lumbar spine. The spinal curvature—lordosis—is very marked both upon standing and walking. The duration of this stage may be several years. From time to time exacerbations occur, often excited by falls, and accompanied by the formation of new abscesses. In protracted cases, all the soft parts about the hip may be seamed with cicatrices from old sinuses. After the disease has gone on to the third stage, cure can take place only by ankylosis.

**Diagnosis.**—The important points in the early diagnosis of tuberculosis of the hip are the gradual evolution of symptoms—the characteristic limp and night cry—and the demonstration of muscle spasm about the joint. The essentially chronic character of the disease should constantly be borne in mind. In the early stages it may be confounded with the result of trauma, with rheumatic fever, poliomyelitis,



osteochondritis deformans juvenilis, periostitis, nontuberculous epiphysitis, or with caries of the lumbar spine. In later stages there is less difficulty in diagnosis, although abscesses resulting from perinephritis or appendicitis have been mistaken for those arising from tuberculosis of the hip.

The x-ray may show nothing at all for several weeks after the onset of the



FIG. 179.—ROENTGENOGRAM IN TUBERCULOSIS OF THE HIP.

Early stage, with rarefaction of the acetabulum and head of the femur (left), but without extensive deformity. Seen from the front.

disease. The most important early signs are atrophy and areas of erosion in the epiphysis of the head of the femur or in the acetabular margin. This is in sharp contrast to the early findings in Perthes' disease (osteochondritis deformans) where early erosion of the bone does not take place but there is molding and flattening of the epiphyseal center of the head of the femur. Sometimes, however, the x-ray does not enable one to decide between the two conditions. Later, the x-ray reveals more extensive destruction of bone.

*Prognosis.*—This is to be considered both with reference to life and limb. The records of the Hospital for Ruptured and Crippled show the mortality of hospital patients with tuberculous hip to be nearly 25 per cent. This includes deaths directly or indirectly traceable to the disease. The causes are nearly the same as in caries of the spine—cachexia from prolonged suppuration, amyloid degeneration, and disseminated tuberculosis or tuberculous meningitis.

Under the most favorable conditions, the disease may be arrested in the early stages, and recovery occur without lameness or any noticeable impairment of joint function. This result, however, is not often obtained, because the disease is usually well advanced before it is recognized, or because of the difficulty in the way of carrying out all the details of treatment. In most cases a successful therapeutic result is purchased only at the price of complete immobilization and eventual bony



ankylosis. Whether this is accompanied by permanent shortening depends mainly on the amount of bone destruction that preceded the commencement of effective therapy.

*Treatment.*—The indications for constitutional treatment are the same as in caries of the spine. The purpose of local treatment is to secure constant and com-



FIG. 180.—ROENTGENOGRAM IN TUBERCULOSIS OF THE HIP.

Late stage, with extensive destruction and deformity (right). Seen from the front.

plete rest for the diseased parts, and to prevent deformity. It should be in the hands of an orthopedic surgeon.

### *Tuberculosis of the Knee*

Tuberculosis of the knee (white swelling) usually begins in one of the condyles of the femur or in the head of the tibia. The pathologic process is much like that at the hip. The degree to which the joint is involved varies in different cases; there may be only a simple synovitis, a suppurative arthritis, or a destruction of the cartilages and articular ends of the bones, synovial membrane, and ligaments; in the advanced stage all traces of joint structure are lost.

If the process remains limited to the bone, recovery may take place with very little impairment of joint function. If suppuration in the joint has taken place, there will be more or less stiffness and fibrous or bony ankylosis. When there is destruction of the ligaments and articular ends of the bones, the limb assumes a characteristic position—the joint is flexed, the tibia is displaced backward and rotated outward, and there is marked over-riding of the femur. Bony ankylosis in this position is sometimes seen.

*Symptoms.*—The earliest symptoms of disease at the knee are usually a slight stiffness of the joint, with a disposition to flexion and slight lameness. At first these symptoms are noticed only occasionally; finally they become constant and



there is pain, which is usually felt in the knee but may be referred to the shin or ankle. In some cases there are starting pains at night, although these are less constant and less severe than in involvement of the hip. Swelling is noticed early, as the diseased parts are superficial. At first this is chiefly of the bone itself; the condyle, usually the inner one, is enlarged, often to a marked degree, before there is any infiltration of the soft parts. Later there is a general fusiform swelling, involving the entire joint and effacing all the normal outlines. Some tenderness upon pressure over the bone affected is present quite early, and there may be atrophy of the muscles of the thigh and calf. The knee is flexed and the thigh slightly rotated outward, a position which secures the most complete relaxation of the joint structures. Abscesses may form anywhere about the joint; very frequently they burrow beneath the tendon of the quadriceps extensor as far as the middle of the thigh. Gradually the deformity increases, until the leg may be flexed at a right angle.

The course of the disease resembles that of osteitis of the hip or of the spine. During periods of remission pain and tenderness often subside for several months so completely as to lead to the supposition that the disease has been arrested. An exacerbation is often excited by a fall or a strain of the joint, or it may follow an attack of acute illness.

*Prognosis.*—The danger to life is considerably less than in tuberculosis of the hip or spine. Death, however, results from the same causes.

With an early diagnosis and proper treatment the disease may, in a considerable proportion of cases, remain limited to the bone, and the resulting lameness and deformity be very slight; but otherwise a certain amount of incapacity results from stiffness of the joint. This may be due either to fibrous thickening or to bony ankylosis. Nearly all patients are able to walk without crutches, and if proper treatment has been carried out there is neither marked shortening nor deformity, although there is always great muscular atrophy.

*Diagnosis.*—The important symptoms for diagnosis are the gradual onset, the early swelling due to enlargement of the bone, and the constant lameness and deformity. The disease may be confounded with rheumatism, with rheumatoid arthritis, with syphilitic synovitis, and even with scurvy. In all these cases the resemblance exists only during the period of exacerbation. The tuberculin test and x-ray are indispensable in establishing an unquestionable diagnosis.

*Treatment.*—The general treatment is the same as in other forms of tuberculosis. Local treatment is an orthopedic problem.

### *Tuberculous Osteomyelitis*

Although occasionally found in the long bones or in the jaw, tuberculous osteomyelitis is rare except in the metacarpals, metatarsals and phalanges (*spina ventosa*, *tuberculous dactylitis*). In the majority of cases the process is confined to a single bone, although it is not exceptional to see five or six affected. In such cases the disease is seldom symmetrical. Beginning in the medullary cavity, the process causes a thinning of the shaft and distortion of its architecture, sometimes even with expansion of the cortical outline. The later changes are inflammation of the periosteum and the soft parts, the formation of abscesses and sinuses, necrosis



and the discharge of sequestra. The entire disease lasts from one to three years, and causes in some cases marked deformity.

Tuberculous dactylitis is essentially a disease of early childhood, being seen most frequently during the second and third years. Often it is the only obvious tuberculous lesion in the body. The disease usually begins as a painless enlargement of one of the phalanges or of the dorsum of the hand or foot. Two or three months may elapse before the size of the swelling attracts much attention. Exceptionally the inflammation is more active and is accompanied by both pain and tenderness. When a finger is involved the swelling is quite characteristic; it is smooth, hard,



FIG. 181.—TUBERCULOUS DACTYLITIS.

uniform, and generally spindle-shaped, extending beyond the involved phalanx. Later there is discoloration of the skin; and if, as often happens, the process goes on to suppuration, the abscess generally opens at the side of the finger, and a curdy pus is evacuated. Secondary infection can scarcely be avoided, and the discharge may continue for weeks or months, with the occasional appearance of sequestra. Under these conditions healing is likely to be accompanied by considerable disfigurement. In some cases the disease is arrested before suppuration occurs.

The condition is sometimes discovered by x-ray before it is clinically manifest. The recognition of dactylitis is usually easy, but as symptoms almost identical may be seen in a syphilitic inflammation the diagnosis rests on general as well as local criteria. Syphilitic dactylitis is more often multiple; it is often symmetrical and almost never goes on to suppuration. Tuberculin and Wassermann tests should both be performed, and the patient should be carefully examined for evidence of tuberculosis or syphilis in other parts of the body.

The prompt institution of an adequate general regimen will initiate healing in



virtually all cases, no matter at what stage of the disease. Unless suppuration is present, no local measures are required. When spontaneous rupture of an abscess appears inevitable a small opening may be made for drainage. Extensive incisions and particularly the curetting of bone are inadvisable. Under conservative treat-

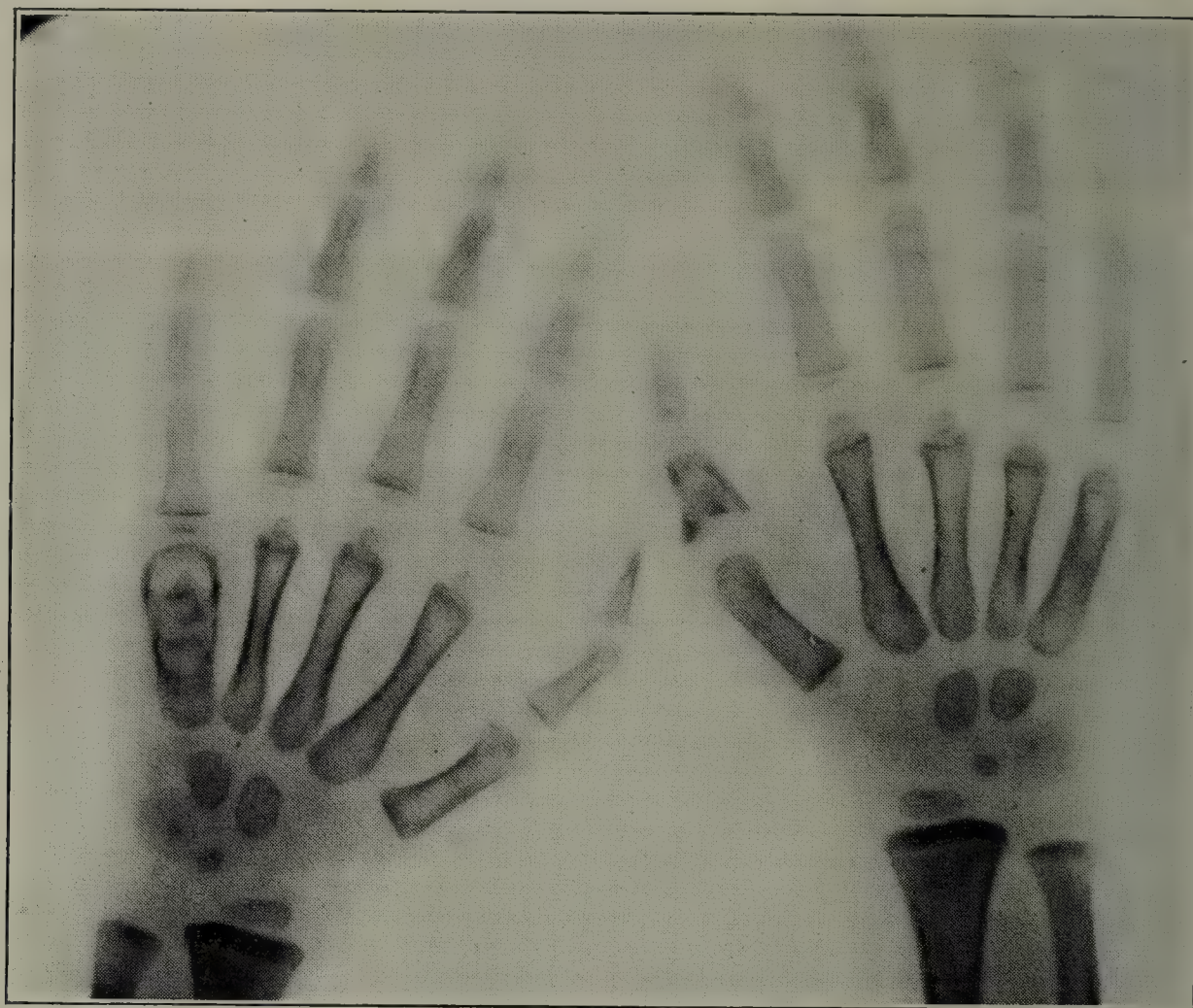


FIG. 182.—ROENTGENOGRAM IN TUBERCULOUS OSTEOMYELITIS.

ment considerable functional as well as anatomical improvement may be anticipated, and in those cases which have not gone on to abscess formation the ultimate recovery may be complete.

#### IX. TUBERCULOUS ADENITIS

Only tuberculosis of the superficial lymph nodes is considered here. It is not common in infancy, although fairly frequent in older children, in whom it may be the only apparent tuberculous lesion in the body.

**Etiology.**—Of 97 cases of tuberculous adenitis in children studied in 1912 by Park and Krumwiede, 51 showed the human type of bacillus and 46 the bovine type. The proportion of cases of bovine infection was much higher in children under five years of age than in those who were older (61 and 38 per cent respectively). These findings showing the frequency of bovine infection are in striking contrast to those obtained by them in other forms of tuberculosis in children and point unmistakably to food or mouth infection, most probably tuberculous milk, as a cause. A striking decrease in the incidence of tuberculous cervical adenitis followed the introduction of pasteurization of milk in this country.

In the great majority of cases the cervical lymph nodes are involved, and generally they are the only ones affected. In 155 cases of tuberculous nodes in the



series reported by Treves, those of the neck were the seat of disease in 145, and the only seat in 131; those of the axilla were involved in 17, but alone only in 4; the groin in 8, and alone in 6. The nodes first affected are most frequently the upper set of the deep cervical group; sometimes, however, it is the superficial nodes of the submaxillary or the parotid group, and occasionally the submental or the pre-auricular. The chain of deep cervical nodes which is involved follows the carotid artery, and often extends some distance below the clavicle. It is seldom that the process is limited to a single node or even to two or three nodes.

The cervical nodes usually become involved as the result of a descending infection from the pharynx. The tonsils and less often the adenoids become tuberculous from sputum coughed up from the lungs or from ingested or inhaled organisms. Tuberculosis of the tonsils and adenoids is more common than has been supposed. MacCready and Crowe found it in 4.2 per cent of 3260 tonsillectomies at the Johns Hopkins Hospital. The infection may not spread to the cervical nodes or these may be only slightly involved. It is only in exceptionally heavy infections that extensive cervical adenitis develops.

**Pathology.**—The process in all tuberculous nodes is essentially a chronic one, but pathologically the cases may be divided into two groups. In one group the process is more rapid, and tends to early caseation and softening; the products of inflammation are mainly cellular, and the amount of fibrous tissue is small. In another group the course is slower, and fibrous tissue predominates, caseation and softening being late or absent.

Tuberculous infection of the lymph nodes may terminate in resolution, encapsulation, calcification or suppuration. The inflammation may subside before caseation has taken place and the inflammatory products undergo absorption. After caseation has occurred the masses may become encapsulated and contract to small fibrous nodules. In other cases caseation is followed by breaking down, liquefaction and an external abscess. The course which the local disease takes will depend upon the intensity of the infection and the resistance of the child. There is seen in many cases a tendency of the inflammation to subside spontaneously about the time of puberty.

**Symptoms.**—In the early part of the disease there are no symptoms but the glandular swelling, and this usually begins gradually. In many of the cervical cases both sides are involved, but as the disease progresses the advanced changes are usually confined to one side. In a certain number of cases the onset appears to be acute, the swelling coming on with fever and reaching a considerable size, often its maximum, in a few days. In such cases there has probably been a small tuberculous node which has escaped notice, which becomes the seat of acute inflammation as a result of pyogenic infection. The acute symptoms last only a short time, but the swelling persists. The course of the disease is characterized by remissions and exacerbations; the swelling may increase for a time and then remain stationary or even diminish, to take a new start from the stimulus of some fresh infection of the mucous membrane with which the nodes are associated, such as an attack of measles or rhinopharyngitis, or simply from a deterioration in the patient's general health. During exacerbation the nodes may be painful and tender and show the usual signs of local inflammation.



The whole course of the disease varies from several months to as many years. As a rule the younger the patient the more rapid its progress. Treves gives three and a half years as the average duration when suppuration occurs, but in infancy the nodes sometimes break down in two or three months. The nodes first affected are usually those situated near the bifurcation of the common carotid artery. Such tumors usually make their appearance just in front of the sternomastoid muscle—sometimes behind it—and at the level of the upper border of the larynx or the hyoid bone. In the more rapid cases the tumors attain a considerable size in three or four months, sometimes in half that time. The usual size reached is from that of an almond to an English walnut. At first the tumors are movable and preserve their distinct outline; later they become adherent, first to the deeper tissues and to each other, finally to the skin, and there is formed an irregular nodular mass in which it is sometimes difficult to make out the individual nodes. As the process approaches the surface there are small spots of softening; then there is distinct fluctuation; the skin becomes discolored and finally gives way, and there is a discharge of thick, curdy pus, which may continue for an indefinite time, until the whole of the broken-down node has been thrown off. This course is repeated with each successive node which breaks down. In cases progressing more slowly the nodes become adherent chiefly to one another, and suppuration is less frequent.

In what proportion of tuberculous lymph nodes suppuration occurs, it is difficult to say. Like other tuberculous lesions in the body, this one is much more frequent than was once supposed; formerly, if nodes did not break down in a few years, they were usually regarded as nontuberculous. We now know that a large number of tuberculous nodes do not break down for many years and some never do. When a node beneath the deep fascia breaks down and there is formed around it an abscess in the cellular tissue, this gradually works its way to the surface. In such cases the sinus continues open for a very long time. If healing occurs before this, the cicatrix soon breaks down. Pyocyaneus infection of the sinus tract is not uncommon.

When abscesses are allowed to open spontaneously, large, irregular, and often very intractable ulcers form. The skin is undermined for a considerable distance, and it has an unhealthy appearance. Such ulcers sometimes continue for many months in spite of all treatment, particularly if the patient's general health is poor. The scars which they leave are large and unsightly, and sometimes positively deforming. Their appearance is quite characteristic. They often have many tabs of skin attached to them; they may form prominent ridges which undergo contraction like those after burns; they are of a purplish-red color, and adherent to the deeper tissues. They are often sensitive and painful. As time passes they contract and become less conspicuous, though they remain throughout life.

The general health of children with tuberculous nodes of the neck is usually but little affected. Although the local process is often extensive, the absence of general symptoms is striking, and the secondary development of generalized tuberculosis is infrequent. At any time in the course of the disease an examination of the throat may show enlarged tonsils, but even when they are not grossly altered, the microscopical examination of serial sections proves them to be tuberculous in a large proportion of the cases.



**Diagnosis.**—The diagnostic features of tuberculous nodes are the age of the patient—usually from two to ten years—the site of the primary swelling, the indolent course, the trifling original cause, and the disposition to slow caseation, softening and abscess. The tuberculin reaction is of great assistance in diagnosis. In some cases where the glands remain small and firm in a child with a positive tuberculin test, one must admit that a differential diagnosis from chronic non-tuberculous inflammation secondary to repeated upper respiratory infections or chronic tonsillitis is not always possible. Calcification visible by x-ray is practically pathognomonic of tuberculosis. Syphilitic disease of the cervical nodes is relatively rare in children. It is recognized by the Wassermann reaction, by the evidence of syphilis elsewhere, and by the effect of treatment. In Hodgkin's disease, groups of nodes in other parts of the body are involved simultaneously or in rapid succession, and there are no signs of inflammation or caseation. Malignant growths are very rare; they increase rapidly, often attaining great size in a few months. The possibility of tularemia should not be forgotten, particularly when the node involved is one that drains a skin area where there has been a wound.

**Prognosis and Treatment.**—General hygienic and dietetic measures are of course of the utmost importance in this as in all other forms of tuberculosis. It is in these cases, however, that heliotherapy gives its most brilliant results. This is well borne out by the experience of Rollier in Switzerland. He states that "under the influence of heliotherapy the healing of tuberculous glands is almost invariably rapid, three to six months usually being sufficient to cause permanent arrest in cases uncomplicated by secondary infection." In other climates and particularly in cities the sun's rays are less efficacious. Ultraviolet radiation with a mercury vapor quartz lamp, although unquestionably a valuable procedure, is not a perfect substitute for heliotherapy. Roentgenotherapy has its enthusiastic supporters. It will often cause greatly enlarged lymph nodes to diminish in size, but the rationale of this procedure is questionable; one of the chief effects of x-ray therapy is the destruction of lymphocytes and the wisdom of this may be doubted.

In regard to surgical treatment there is a striking lack of unanimity. Some surgeons advise radical excision and others feel that it should never be employed. The evidence from published statistics is far from conclusive. In New York City Dowd reported 309 patients treated by more or less radical excision, of whom 65 per cent were apparently cured; their course was followed for several years after operation. In the same locality Hanford reported 141 patients treated with hygienic measures, radiation and only conservative surgical procedures; he obtained arrest in 71 per cent within ten months. In general, radical operations are losing favor and, we believe, justly so. When there is extensive ulceration and periadenitis, attempted removal may only spread the infection and is contraindicated. When the nodes remain discrete, conservative measures are usually successful.

In most instances removal of possible foci in the tonsils and adenoids, diet and actinotherapy will soon cause improvement. Should this fail to occur and the glands continue to enlarge and yet remain discrete, operation may be considered. In some instances where there is lack of coöperation as regards hygienic measures and actinotherapy, removal of the glands may be preferable.



When there is fluctuation, aspiration is always preferable to open incision; the latter only leads to secondary infection and chronic sinus formation.

X. TUBERCULOUS MENINGITIS

Tuberculous meningitis is a tuberculous inflammation of the pia mater of the brain, sometimes involving also that of the cord. It is by far the most frequent form of acute meningitis seen in young children. In our hospital experience, apart from epidemics of meningococcus meningitis, 70 per cent of the cases of acute meningitis have been tuberculous. In our experience it is uniformly fatal.

Relatively rare in the first six months of life, the disease rapidly becomes more common, reaching the peak of its incidence soon after the end of the first year. Three of our cases occurred in infants under three months of age. As a rule in

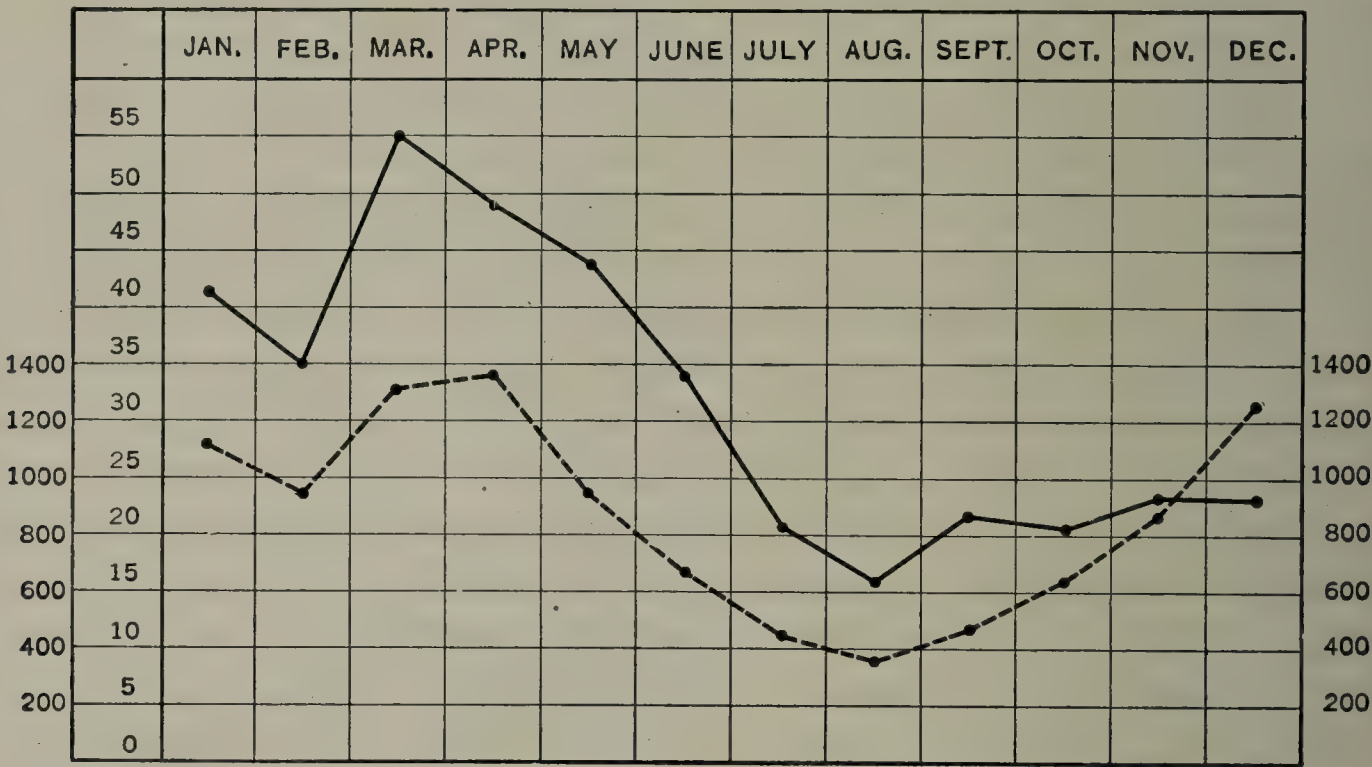


FIG. 183.—SEASONAL OCCURRENCE OF 400 CASES OF TUBERCULOUS MENINGITIS.  
Lower curve, deaths from pneumonia, New York City, during one year.

young patients the disease is part of a generalized miliary tuberculosis; but there are exceptions, in which the only miliary lesions are those in the meninges (p. 1035). Although it is not infrequent to see meningitis without symptoms of tuberculosis elsewhere, we have never failed at autopsy to find other tuberculous lesions in the body, at least a focal lesion in the lung or bronchial lymph nodes.

Tuberculous meningitis in our experience occurs much more often in the winter and spring months than at other seasons (Fig. 183). The most plausible explanation of this seems to be that, under the influence of acute respiratory infections of the cold season, a latent tuberculous focus becomes active and dissemination ensues. At the time of invasion many of these children appear to be in the best of health.

Of 32 cases in which the type of organism was determined by Park and Krumwiede in the Research Laboratory of the New York Health Department, in 30 the bacillus was of the human type, in 1 it was of the bovine type, and in 1 both types were present.

**Pathology.**—There is an edematous, gelatinous inflammation, nearly always most extensive over the base of the brain. The exudate usually extends in a layer



of some thickness into the fissure of Sylvius on each side, and can be seen in patches following the course of the vessels as they emerge from the fissures on the lateral surface. Opaque, slightly yellowish flecks and masses of a little larger size indicate the presence of necrotic caseous areas. Fibrin, fluid and mononuclear cells are the most conspicuous constituent elements. The cells form clusters, often rather large, about the blood vessels. The infiltrated vessel walls often become necrotic. A narrow zone of cellular infiltration quite frequently is to be seen immediately beneath the endothelial lining of the vessel.

In many cases polymorphonuclear leukocytes are sprinkled through the exudate, but only rarely are they a pronounced feature. In those of longer duration epithelioid cells form sheets of tissue and there is a fibrous tissue formation. In rare instances the lesion is mainly proliferative, made up in greater part of epithelioid cells and fibrous tissue. Tubercles and giant cells are usually present in such a case.

The brain substance immediately beneath the pia is swollen and edematous. The vessels penetrating the brain are surrounded for a short distance by layers of mononuclear cells occupying the perivascular space. Minute foci of anemic necrosis are often present in the still deeper layers, apparently the result of compression or occlusion of small vessels. In spite of the fact that necrosis is commonly found in the walls of vessels of moderate size, thrombosis and larger areas of infarction are relatively infrequent, although they do occur.

Owing to the location of the exudate and duration of the disease, the foramina through which the cerebrospinal fluid escapes into the meninges may become blocked, and moderate dilatation of the cerebral ventricles is a frequent finding. The lining ependyma is found studded with tiny translucent granules of barely visible size.

It was formerly taught that tuberculous meningitis was caused by hematogenous distribution of bacilli to the meninges. This view failed to explain instances of meningitis with no miliary lesions elsewhere and cases of miliary tuberculosis in which the meninges were spared. Rich and McCordock maintain that meningitis is always the result of the breaking down of a larger focus in the brain with dissemination of organisms by the spinal fluid. They point out that experimentally it is impossible to produce meningitis by introducing bacilli into the circulation; it can be brought about only by direct inoculation of the nervous system. In the autopsies at the Johns Hopkins Hospital they have been able to find a larger parent lesion in the brain in practically every instance. Often a particularly thick cluster of miliary lesions deep in one of the fissures gives a clue to its location. Occasionally such a discharging focus is situated in the choroid plexus. Rarely an extension through the dura from a carious bone is the infecting source of organisms.

Solitary tubercles of greater size, sometimes as big as a walnut, may be found in older children in cases of meningitis. They may be buried deep in the substance of the brain or cerebellum, or may reach the surface.

**Symptoms.**—In about two-thirds of the cases the onset is gradual; but in a considerable number of those classed as abrupt, careful inquiry will elicit a history of previous indisposition. The most frequent early nervous symptoms are: disinclination to play, drowsiness, or sometimes constant fretfulness or irritability. Often



there is a complete change in disposition. In a case under our observation this was most striking: a little girl previously devoted to her mother, could not endure her presence in the room. Sleep is restless and disturbed; there may be grinding of the teeth. Older children often complain of headache. At all ages, but particularly in infancy, early digestive symptoms are prominent. There are seen frequent attacks of vomiting without apparent cause; the bowels are generally constipated and the appetite is almost entirely lost. Usually there is also a slight but continuous elevation of temperature. Indefinite symptoms may last for four or five days, or they may be spread over two or three weeks without perhaps being sufficiently severe to attract much notice. Finally, unmistakable evidence of brain disease develops. The early disturbances are often ascribed to dentition or to indigestion.

In most cases the first pronounced cerebral symptom is persistent and increasing drowsiness; exceptionally it is an attack of general convulsions, followed in a few hours by stupor. Often a period of irritative symptoms is present, lasting several days. There is headache, usually located in the frontal region, and occasionally photophobia; sometimes pain is indicated by the child's suddenly screaming out at night, which may be repeated many times without his waking; sometimes during the greater part of the time for two or three days these frequent screaming attacks may be repeated. The skin is somewhat hyperesthetic; the reflexes are apt to be exaggerated; the muscles of the neck may be rigid and the head is drawn back, or there may be rigidity of the extremities. The pupils are normal or contracted; there may be nystagmus. The child is fretful, wishes to be left alone, and cries if disturbed. In some cases these symptoms are so marked as strongly to suggest meningococcus meningitis. They may alternate with periods of marked apathy and dullness. During this stage there is occasional vomiting, and the bowels are obstinately constipated. The pulse is usually somewhat accelerated, but may be slow and occasionally it is irregular. The respiration is of normal frequency, but a careful observation during sleep or perfect quiet will often show a distinct irregularity which is very significant. The temperature is usually but little elevated, ranging from 99° to 100.5° F. When a high temperature is seen, it is usually due to tuberculosis elsewhere than in the brain, or it may be associated with convulsions.

As the disease advances, the irritative symptoms subside, and the stupor becomes deeper and more continuous. If undisturbed, the child may sleep a great part of the time, but can be roused, and then appears quite rational. Finally the stupor becomes so profound that the child cannot be roused at all. Active delirium is rare. The pupils respond slowly to light or not at all; they may be unequal; occasionally there is seen strabismus, ptosis, or paralysis of the face. More often there is hemiplegia, or paralysis of one arm or leg. Such paralyzes are often transient, disappearing after a day or two. Automatic movements of the extremities, particularly of the arms, are frequent. Muscular twitchings may be noticed. Opisthotonos is marked and well-nigh constant. In infants the fontanel is tense and bulging. In older children especially, the abdomen is retracted, owing to dehydration and starvation. After drawing the fingernail along the skin of the abdomen, there appears a distinct red streak, which remains for several minutes. This is the *tache cérébrale*, and it is almost always present. Other vasomotor disturbances may be seen—flushing or irregular mottling of the skin. The reflexes are variable; in



the early part of the disease they are usually increased, later they are diminished or abolished. The pulse now becomes slow and irregular, often intermittent. The respiration is almost always irregular; a very characteristic type consists in the movements becoming deeper and deeper until there is a sigh, followed by a complete arrest of respiration for several seconds. The phenomenon is then repeated. An examination with the ophthalmoscope usually shows the presence of choked disks, and in a very considerable number of the cases, if they are closely studied, tubercles may be seen in the choroid, generally at the periphery. In one of our cases tubercles were visible on the iris, but this is rare. The blood picture in this disease is fairly characteristic. From 230 observations made in our hospital service, it was shown that early in the attack the total leukocytes are only slightly increased; they may be even below normal. As the disease progresses they increase

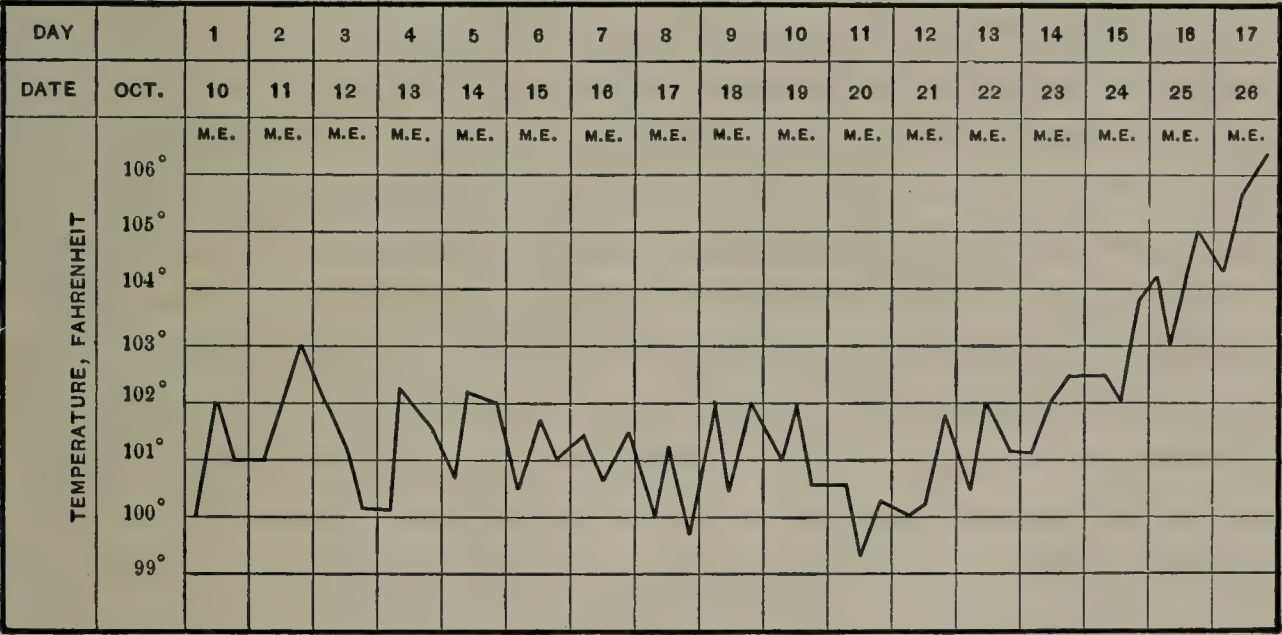


FIG. 184.—TEMPERATURE CURVE IN TUBERCULOUS MENINGITIS.  
Boy, twenty months old; death on seventeenth day.

in number, the average during the last week of the disease being 30,000. The proportion of polymorphonuclears also shows a marked increase. The early range is 60 to 65 per cent; during the last week it is from 70 to 85 per cent.

The progress of the disease is subject to great variations, especially in children over two years old. The advance of symptoms is slower and is interrupted by periods of remission which may continue two or three days. After being in quite deep stupor, a child may recover consciousness and even sit up and play with toys, leading to the view that an error in the diagnosis has been made. But this respite is only temporary; soon the child passes again into coma.

From this time the duration of the disease is from three to ten days. The child cannot be roused at all. The pupils are widely dilated, and do not respond to light. There is general muscular relaxation. There may be retention of urine. Deglutition is difficult, often impossible. The respiration is more rapid, but still irregular. The pulse becomes very rapid and feeble, often 160 to 180 a minute. Toward the end the temperature often rises rapidly to 104° F., sometimes to 106° or 107° F. (Fig. 184). Death usually takes place from exhaustion in deep coma; or convulsions develop and continue from twelve to twenty-four hours until death. Sometimes a patient will live for days in a condition of prostration so extreme that death is



hourly expected. A rapidly rising temperature or the occurrence of late convulsions usually indicates approaching death. Of 57 cases, 50 died in coma, 7 in convulsions. The entire duration of the disease from the beginning of definite nervous symptoms is rarely over three weeks, and in infants it is usually shorter than this.

**Diagnosis.**—Nothing is more difficult than the recognition of tuberculous meningitis in its early stages. On the one hand, the indefinite symptoms belonging to this period of the disease are frequent in young children suffering from digestive disturbances alone. Cases of cyclic vomiting may present many of the symptoms of meningitis. The most suggestive symptoms of tuberculous meningitis enumerated in the order of their frequency are as follows: persistent drowsiness, obstinate constipation, vomiting without apparent cause, irregular respiration, irregular pulse, convulsions, opisthotonos, and a mild elevation of temperature.

A positive diagnosis is made only by lumbar puncture. The changes in the spinal fluid are present even in the prodromal stage of the disease. As a rule the spinal fluid pressure is considerably elevated. The fluid is usually perfectly clear, less often slightly turbid with a ground-glass appearance; it is colorless except when complications are present. On standing, a delicate coagulum forms, usually adherent to the surface of the fluid and at one or two points of the bottom of the tube. This is often referred to as the "film" or the "web." In a few cases no film forms; under these conditions a slight sediment may be found after long standing. As compared with other forms of acute meningitis the cells are few in number. The usual cell count is from 100 to 250 per cubic millimeter, though the possible range extends far beyond these limits. Nearly all the cells, over 90 per cent in most cases, are mononuclear. A predominance of polymorphonuclear cells is, however, occasionally met with, particularly in those cases with unusually high cell counts. There is invariably an increase in the amount of globulin, though after repeated drainage the content may not be much above normal. Most fluids show a decided diminution in glucose, which falls to from 35 to 45 per cent of the blood sugar level. Shortly before death it may rise to 60 or 70 milligrams per 100 c.c. We have seen two instances of tuberculous meningitis associated with subarachnoid block and the Froin syndrome.

Tubercle bacilli are regularly present in the fluid, although in the early stages they are few in number and often difficult to find. At the height of the disease by careful examination they can be demonstrated microscopically in nearly every case. They were found in 135 out of 137 consecutive cases of tuberculous meningitis at the Babies' Hospital. They are more numerous late in the disease. The technic is important.<sup>8</sup> In most cases the number of bacilli present is not large and a prolonged search may be necessary; but not infrequently they are sufficiently numerous to be discovered in a few minutes. The demonstration of bacilli by culture or guinea-

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<sup>8</sup> Fluid should be drained into several tubes, the first two containing the amount necessary for cell count, globulin test and other procedures, the rest containing as much fluid as can safely be obtained. These last are set aside, preferably in an incubator, until a film has formed. This may occur in a few minutes or may take several hours. The fluid and coagulum are poured into a sterile Petri dish and a clean slide is submerged in it so that the coagulum can be teased onto the slide with a minimum of handling. The slide is then removed, the film dried in the air, fixed by heat, and stained. In the absence of film formation, one may precipitate the proteins by the addition of an equal volume of 95 per cent ethyl alcohol. The resulting cloud is centrifuged down at high speed, which carries most of the organisms to the bottom of the tube. The supernatant fluid is decanted and some of the sediment transferred to a clean slide and fixed with a minute amount of egg albumin or horse serum and heated and stained in the usual way.



pig inoculation requires too much time to be of practical value. Before either of these methods can yield a definite result, the clinical course has usually made the diagnosis unmistakable.

Allergy is high early in the disease and the skin test is hence of great diagnostic importance. Toward the end allergy may wane and negative results are frequently obtained with the ordinary dosage (0.1 milligram of tuberculin).

The demonstration of tuberculous lesions in other parts of the body, as by x-ray examination of the lungs or examination of the gastric contents for organisms, is helpful when positive but has little value when negative. Most significant findings are the discovery of papulonecrotic tuberculids or of choroidal tubercles.

A number of other diseases give spinal fluid findings at first resembling those of tuberculous meningitis (see table on page 802). The most deceptive are various forms of encephalitis, including lead encephalopathy and the encephalitic form of poliomyelitis, certain insidious forms of meningococcus meningitis, the meningo-encephalitis sometimes seen with mumps, and rare cases of neuroblastoma associated with a pleocytosis.

**Prognosis and Treatment.**—Although there have been reported a few instances of recovery after tubercle bacilli have been found in the spinal fluid, such an outcome is not to be expected. The reported recoveries have all been in older children; instances in which bacilli have not been found cannot be accepted. Only a single instance of recovery in a proved case has been observed in a period of 24 years at the Johns Hopkins Hospital.

### *Tuberculoma of the Brain*

Solitary tubercles in the brain substance occasionally give rise to focal neurological syndromes and even at times to pressure symptoms independently of tuberculous meningitis. They are somewhat more common in the cerebellum than in the cortex; occasionally they are found in the medulla. Clinically it is difficult to differentiate them from neoplasms. The spinal fluid remains normal or shows only an alteration of pressure. The diagnosis, depending as it does largely on associated tuberculous lesions elsewhere in the body, can rarely be made with certainty by clinical means alone. Even the demonstration of calcification by x-ray is not pathognomonic, since certain neoplasms may show this. Conservative treatment is generally preferable to operative removal.

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## CHAPTER CXXXVII

### SYPHILIS

Syphilis is a communicable disease caused by the *Treponema pallidum* (sometimes spoken of as the *Spirochaeta pallida*). The organism, first described by Schaudinn in 1905, has been demonstrated in practically all varieties of syphilitic lesion. It is, however, difficult to find in some of the late manifestations of the disease.

In infancy and childhood both the acquired and the congenital forms of syphilis are seen.

#### ACQUIRED SYPHILIS

While acquired syphilis is much less frequent than the congenital variety, it is by no means a rare disease in early life. An infant may be infected by the mother during parturition, but this is extremely rare and can take place only when there are lesions upon the mother's genitals. Infection is more likely to be from a mother who contracts syphilis subsequent to the birth of the child, and may occur through nursing or accidental contact by kissing, etc. In either of these ways, or from a venereal sore upon the nipple, a child may be infected by a wet-nurse. Whether syphilis can be communicated through the milk when the nipple is perfectly healthy and free from fissures, is exceedingly doubtful.

Syphilis may be communicated directly from a syphilitic child to one who is healthy, by kissing, by sexual contact, or indirectly by means of bottles, spoons, cups, clothing, etc. The latter mode of infection occasionally occurs in institutions. Vaccination was formerly a not infrequent mode of communicating syphilis, but has been practically eliminated by the general introduction of bovine virus. Cases have been recorded where the disease has been conveyed by the rite of circumcision, either from the mouth or the instruments of the operator. We have seen several instances of syphilis acquired as the result of a transfusion. These are usually recognized early and the prognosis is correspondingly good.

The relative frequency of the different sources of infection is shown by Fournier's statistics of 42 cases. The source of infection was the parents in 21; nurses, in 8; servants, in 4; sexual contact, in 4; vaccination, in 2; other children, in 2; a physician, in 1. The ages at which the disease was acquired in this series of cases were as follows: during the first year, 19; during the second year, 10; during the third and fourth years, 7; from the fifth to the fourteenth year, 6.

The symptoms of acquired syphilis in children are similar to the same disease in the adult. Except in those cases where the disease is acquired by transfusion, a primary sore is present at the site of infection, which is most frequently the lips, the mouth, or some part of the face; very rarely is it seen on the genitals. There are few individual symptoms belonging to congenital syphilis which may not also be present when the disease is acquired. The eruption may be indistinguishable from that of congenital syphilis. The course of acquired syphilis, how-



ever, is milder and a fatal termination is rare. Fournier states that of his 42 cases only 1 died of malnutrition. This marked contrast to congenital syphilis is due chiefly to the fact that in the acquired variety the child is usually strong and vigorous, while in congenital syphilis the infant is often premature and generally feeble.

Tertiary symptoms may appear at any time from three to twenty years after the original infection.

The treatment is the same as that of congenital syphilis.

### CONGENITAL SYPHILIS

**Etiology.**—If either parent is actively syphilitic at the time of conception the child is almost certain to be syphilitic unless the mother receives early and efficient treatment. If the mother is suffering from secondary symptoms during the first half of pregnancy transmission is almost certain. If the mother acquires syphilis during the second half of pregnancy the child may escape. On the other hand the absence of clinical symptoms on the part of the mother does not insure the birth of a healthy child, as many pregnant women without recognizable symptoms but with a positive Wassermann reaction give birth to syphilitic children. Even without treatment of the mother the disease is not always transmitted and there is a tendency for it to be less severe in successive children, though a child may escape and subsequent children be syphilitic.

The transmission of syphilis from the father without the intermediate infection of the mother was once held to be not only possible but frequent. This, however, has never been conclusively demonstrated. In 1837 Colles enunciated the following proposition, the truth of which has been abundantly verified since his time: "A newly born child affected with inherited syphilis, even although it may have symptoms in the mouth, never causes ulceration of the breasts which it sucks if it be the mother who suckles it, although continuing capable of infecting a strange nurse." From the careful analysis of many cases and with the great assistance derived from the Wassermann reaction the conclusion seems irresistible that the mother who bears a syphilitic child is immune to syphilis for the reason that she herself is invariably suffering from syphilis. The mother in these circumstances cannot be inoculated either by her syphilitic nursing infant or otherwise.

There are a number of recorded instances in which a healthy wet-nurse has been infected by a syphilitic infant. We have ourselves seen one such instance. The disease has been contracted by physicians and nurses from handling infants with florid eruptions, the infection usually gaining entrance through an insignificant wound in the finger and producing there a typical primary lesion. Such examples of contagion are fortunately rare, and many writers of large experience state that they have never seen one. While the danger of infection from congenital syphilis has without doubt been exaggerated, strict precautions are advisable to protect those who care for infants with open lesions—particularly of the skin and mucous membranes.

**Pathology.**—Death may occur from syphilis, and yet the autopsy may reveal no characteristic anatomical changes, and in fact there may be no demonstrable changes in any of the organs except the presence of the spirochetes. Such instances



have been described in infants dying at term or in the first weeks of life. As a rule, however, there are widespread lesions all over the body. The lesions of early congenital syphilis cannot be classed as either secondary or tertiary in character; characteristics of both are present. In late congenital syphilis, the lesions are definitely tertiary.

*Osteochondritis*.—This is a most characteristic lesion of early congenital syphilis. When a typically affected long bone of a newly born or young infant is sliced longitudinally, the examiner is struck by the presence of a broad, irregular, granular, yellow zone, lying across the end of the shaft at its junction with the proliferative cartilage. This yellow zone is due to the presence of masses of trabeculae of calcified cartilaginous substance without any coating of bone. From the presence of this yellow granular zone the diagnosis of congenital syphilis can often be made on gross inspection alone.

The pathology of syphilitic osteochondritis and periostitis is not clear because the underlying processes set in operation by the *Treponema pallidum* are unknown. But the essential underlying process seems to be a derangement in the nutritive supply of the cartilage and the growing shaft, and the characteristic changes appear to be secondary to this. Under normal conditions growth at the cartilage-shaft junction is an intricate process and depends on the orderly development of the proliferative cartilage and the equally orderly invasion of the latter by the steadily advancing capillary network of the shaft with its accompanying cells. In congenital syphilis, as in rickets, this orderly interplay is lost and in both diseases growth at the cartilage-shaft junction goes awry. In rickets the cause is a general disturbance in the calcium and phosphorus metabolism, whereas in congenital syphilis it is due to the effects of syphilis on the circulatory system of the cartilage and bone, as already indicated.

Although the exact mechanism by which the changes in syphilitic osteochondritis are brought about is obscure, the main results seem clear and are quite regularly present. In the first place, in many cases of congenital syphilis the proliferative cartilage does not develop normally. The cartilage canals, which are composed of the blood vessels entering the resting cartilage from the perichondrium and their thick envelopments of connective tissue, become much enlarged and cease to be efficient agents for the even diffusion of lymph. The cells of the mature proliferative cartilage are small and deformed, the columnar arrangement is irregular or actually lost and there is an irregular and apparently often excessive formation of intercellular substance. These changes are important, because the deformity of the proliferative cartilage may make its invasion by the capillaries difficult and the increased intercellular substance furnishes more than the usual material for calcification, causing the deposition of lime salt in the cartilage to be unusually heavy. Moreover, the cells of the proliferative cartilage in the neighborhood of the terminations of the cartilage canals seem to mature earlier than the cells further removed, with the result that lime salts deposit in the cartilage lying around the ends of the cartilage canals in advance of the rest of the cartilage. In the second place, osteoblastic activity along the cartilage-shaft junction is slight or ceases altogether. Though one may find osteoblasts along the trabeculae of calcified intercellular substance, they are not active, for the trabeculae of calcified inter-



cellular substance are not layered with bone as under normal conditions. In the third place, in the region of the cartilage-shaft junction the *destructive* processes, which are as essential to orderly bone growth as the constructive, are in abeyance while a little further away in the shaft they seem to operate in an abnormally active and lawless manner. Finally, one finds all through the involved end of the shaft an irregular growth of connective tissue which has sprung up in place of normal marrow and has replaced the trabeculae of calcified cartilage or bone wherever the latter have disintegrated and disappeared. The connective tissue is commonly spoken of as syphilitic granulation tissue, but it does not differ from ordinary connective tissue, except that perhaps here and there in it can be found evidences of syphilis in the form of thickened blood vessels with clusters of small round cells scattered about them.

We shall now trace these changes in a little more detail, to see how they are related to each other and to the phenomena seen in the x-ray film. In the normal bone of the growing infant the majority of the trabeculae of calcified intercellular substance, soon after their formation in the provisional zone of calcification of the cartilage, are destroyed by the agencies of the shaft. To take a hypothetical example, if in the normal bone one finds in the provisional zone of calcification 50 trabeculae of calcified intercellular substance per millimeter, 2 millimeters away in the substance of the shaft one will find only 10. In other words, in this hypothetical example, 4 out of every 5 trabeculae have disintegrated and disappeared close to the cartilage-shaft junction. In congenital syphilis, as already pointed out, this orderly systematic destruction of the trabeculae of calcified intercellular substance, which probably requires for its occurrence the formation of a layer of osteoblastic cells (endosteum) over their surface, fails to occur. The result is that as the cartilage grows and produces more and more calcified trabeculae, the latter keep accumulating in an increasing mass at the end of the shaft. If one looks at the histological preparation in a typical example, one sees at the end of the shaft a thick, dense lattice-work of trabeculae composed entirely of calcified intercellular substance without any covering of bone. This dense lattice or thicket of calcified cartilaginous material is responsible for the dense shadow at the end of the bone seen in the x-ray film, the shadow which is so characteristic of congenital syphilis. The jags or points in the shadow which, when present, always occur on the cartilage side, are due to the peaks produced by the deposits of lime salts around the terminations of the cartilage canals. Indeed, wherever in the x-ray picture one sees an angular shadow protruding from the end of the shaft, one knows that a cartilage canal lies opposite that point and that calcification has extended toward the canal or even into it in advance of the calcifying process in the adjacent portion of the cartilage. Though the destruction of trabeculae of calcified intercellular substance of the cartilage in the immediate vicinity of the cartilage-shaft junction does not take place, as it should do normally, the destruction which takes place a little farther down in the shaft is usually so extensive and lawless that its effects might be compared to the ravages of a malignant tumor. There, always in scattered foci, the calcified material, including both calcified cartilaginous intercellular substance and bone trabeculae, disintegrate and disappear, with the result that between the lattice formation, on the one hand, and the end of the normal-appear-



ing part of the shaft (the part which antedated the syphilitic infection and has remained essentially normal), on the other, areas develop in which all lime-salt-containing tissues have disappeared and their places and the marrow spaces between them have become completely overgrown by a thick tangle of connective tissue. The disintegration of the calcium-containing trabeculae is responsible for the zone of rarefaction in the x-ray film in congenital syphilis, which can be seen to lie characteristically between the dense shadow cast by the lattice and the ending of the normal part of the shaft. But in order to understand fully both the microscopic and x-ray changes at the cartilage-shaft junction in congenital syphilis, one must realize that the destructive process which leads to the production of the zone of rarefaction varies greatly in severity and in the wideness of its distribution. At one extreme, the destructive process is so slight that it may be considered absent, so far as gross appearances are concerned. Under such circumstances in the x-ray film a terminal zone of greatly increased density due to the thick lattice of calcified intercellular substance abuts on normal-appearing shaft. At the other extreme, the destruction has been so great that between the cartilage and the ending of the normal part of the shaft almost all of the calcium-containing tissues, including the lattice itself, have been removed and replaced by connective tissue. When this has occurred, one sees in the x-ray film between the bright line produced by the provisional zone of calcification of the cartilage (visible in normal bone) and the ending of the normal part of the shaft a space which, at first glance, seems almost free from shadow but on closer inspection is found to contain faint shadows of trabecular aggregations which have escaped the destructive process. In the great majority of cases of early congenital syphilis destruction takes place over a wide area (there is a well-marked zone of rarefaction in the x-ray film) and involves the lattice as well as the subjacent part of the shafts, but involves it in an irregular manner, leaving large parts or fragments intact. In the great majority of cases, then, the end of the shaft, as seen in the x-ray film, presents a dense terminal shadow which, however, is broken and irregular and varies much in thickness. The breaks and irregularities in the shadow are due to the fact that at various points the destructive process has extended into the lattice itself and caused its disintegration in localized areas with replacement by connective tissue. If the syphilitic process declines and then again intensifies, one may find two zones of dense shadow, corresponding to two lattice formations alternating with two rarefied zones.

*Epiphyseal Separation.*—Separation of the epiphysis in congenital syphilis is really a misnomer, because the separation always occurs through the end of the shaft—that is, the epiphysis always carries with it a part of the lattice of calcified cartilaginous intercellular substance, for the reason that the break occurs through the lattice or through the subjacent zone of rarefaction. The reason the break always occurs at the points indicated is that the trabeculae of calcified cartilaginous intercellular substance have never been reënforced by fiber-containing bone, as the result of the cessation of osteoblastic activity, and are as brittle as plaster of paris and fracture as readily. The separated epiphysis may be carried backwards, forwards, or to the side. But quite commonly the shaft becomes impacted into it, since the intervening rarefied bone and the lattice crumple and are



compressed and extruded laterally. The periosteum at the site of the impaction, which has suddenly been rendered redundant, becomes pushed outwards into a fold which might be compared to the circular fold which forms in a loose stocking when the latter begins to come down. These phenomena can be clearly seen in the x-ray film.

*Periostitis.*—The changes in periosteal bone formation which occur in congenital syphilis consist in the formation of one layer of periosteal bone over another. The thickenings of periosteal origin in congenital syphilis, which do not ordinarily show marked characteristics of syphilis in their finer structure, differ from those seen in rickets in that they occur here and there; they do not extend evenly over the entire length of the bone. The periosteal thickenings in rickets usually extend from one end of the shaft to the other in a straight line or even curve because their formation is determined by conditions of stress and strain. The reason for the irregularity of the periosteal new formations in congenital syphilis presumably is that the spirochetes are irregularly distributed. The irregularity of the periosteal thickenings often serves to distinguish congenital syphilis from rickets in the x-ray film. It must be remembered, however, that, when rickets complicates congenital syphilis or when the bone in congenital syphilis becomes very much weakened from the disease itself so that stress and strain become stimulating factors, thick envelopments of periosteum running the entire length of the bone may form, as in rickets. Indeed, when congenital syphilis is complicated by rickets, periosteal thickenings may reach a magnitude seldom seen in rickets alone.

*Other Bone Lesions.*—Anywhere in the shaft or, indeed, in the thickened periosteum, local areas of destruction of the lime-containing portions of the bone may develop, giving rise in the x-ray picture to holes or large moth-eaten areas. Presumably in these areas of rarefaction nests of spirochetes are present and the syphilitic process is especially active. It is the custom to speak of these localized areas of rarefaction as being due to the presence of gummata. But usually on histological examination one finds that all the trabeculae are gone and nothing is present except the so-called syphilitic granulation tissue. In older children, when the syphilitic process has assumed a tertiary form, true gummatous inflammations may be found in the bones.

In the fetus the cartilage-shaft junctions are affected by syphilis in proportion to the rates of growth. For example, the lower end of the radius is more affected than the upper end because it grows twice as rapidly. But after birth the syphilitic process develops with greater rapidity at some cartilage-shaft junctions than at others, so that the extent of the lesion no longer corresponds to the rate of growth. In children several months old it seems as if the lesions were apt to be especially extensive at points where the bone is subjected to the pull of powerful muscles—for example, in the olecranon process or in the upper ends of the tibiae.

In the fetus congenital syphilis manifests itself chiefly as a syphilitic osteochondritis, and only occasionally as a periostitis. But in postfetal life the periosteal thickenings often become greatly developed and sometimes are the only evidence of the disease in the bone.

Contrary to the usual impression in this country, in infants a month or more of age, rickets is often associated with congenital syphilis, not because there is any



specific connection between the two diseases but because many congenital syphilitics are premature infants and have the same predisposition to rickets that premature infants have in general. In addition they are rendered liable to rickets because, in the presence of the syphilitic infection, they are unable to regulate the calcium and phosphorus metabolism to meet the requirements of the growing skeleton. In congenital syphilis it is most important to understand that there is no disturbance in the calcium and phosphorus metabolism and that congenital syphilis is as far removed from rickets as scarlet fever.

*Liver.*—This is probably more frequently involved in the fetus and newly born infant than any other organ. The syphilitic lesions of the liver consist in an interstitial hepatitis, a gummatous hepatitis, or a combination of the two varieties. In the interstitial form, which is most common in infancy, the liver is enlarged, frequently very much so, and firm. The capsule is often thickened and there may be adhesions to other abdominal viscera. On cross section the markings are indistinct. Microscopically, there is a great increase in connective tissue, which is diffusely scattered throughout the whole organ and even between the individual liver cells. The liver-cell strands are reduced to small isolated bands of cells with many nuclei. The lobar arrangement is entirely distorted. Areas of blood formation indicate the retardation of development. The liver retains some of the characteristics of the fetal organ even in infants who are not premature. There may also be bands of connective tissue invading the liver in different directions. As the connective tissue contracts, an irregularity of the surface of the liver develops. Groups of miliary syphilomata may also be found. The gummatous form is not frequent in early infancy. In this there may be miliary syphilomata with interstitial changes, and in addition the formation of small or large gummatous tumors which may be softened at the center. They are surrounded by zones of new connective tissue and the liver cells are atrophied. Amyloid changes may be present.

In the late form of congenital syphilis, usually seen in children over four or five years old, the liver is occasionally affected. The lesions resemble those of the acquired variety. There are found cirrhotic changes, which may be diffuse or circumscribed, and gummatous lesions which vary from a minute size to that of a cherry; there may be amyloid degeneration.

*Spleen.*—This is almost invariably much enlarged in newly born children with syphilis and in syphilitic fetuses, but nothing characteristic is found under the microscope. In older children the enlargement of the spleen may be even greater. The organ may be the seat of interstitial changes, with adhesions to other viscera, and sometimes there may be small gummatous deposits. These changes are rare in children under two years of age.

*Respiratory System.*—Rhinitis is seen both in early and late congenital syphilis. In early syphilis there is a subacute catarrhal inflammation, sometimes with the formation of superficial ulcers. In late cases there are occasionally found gummatous lesions, the breaking down of which leads to deeper ulceration, involvement of the periosteum, cartilages and bones, causing perforation or partial destruction of the septum and necrosis of the bones. These changes produce falling in of the bridge of the nose, and other deformities. Lesions of the larynx, other than a chronic catarrhal inflammation, are rare in early syphilis. In late syphilis there may



be in addition involvement of the cartilages with gummatous lesions; but these are infrequent as compared with conditions found in adult life. The parts most often involved are, in order, the epiglottis, the aryteno-epiglottic folds and the posterior laryngeal wall. Usually there is only perichondritis. In more severe cases there is breaking down of gummatous lesions with ulceration followed by stenosis; or there may be simply thickening of the vocal cords and occasionally the formation of small papillomatous tumors.

In the trachea and larger bronchi lesions similar to those described in the larynx may be present. In syphilitic infants who are stillborn and in those who die soon after birth, there is occasionally found in the lungs what is known as "white pneumonia." The lungs are nearly white or slightly red. They are firm and contain little or no air. The alveoli are filled with desquamated cells and leukocytes. There is an increase in the connective tissue of the alveolar walls, bronchi, and blood vessels. There may also be gummata scattered through the lungs. These are usually small.

*Nervous System.*—Syphilis may affect the meninges, the blood vessels or the brain itself. There may be merely a diffuse thickening of the meninges, with which there is usually associated a certain amount of encephalitis, or there may be miliary gummata scattered throughout the meninges, but especially at the base. As the result of the chronic syphilitic meningitis, adhesions may form at the base, obliterating the foramina of Magendie and of Luschka and at times leading to hydrocephalus. Syphilitic endarteritis is very common and consists in a thickening of the vessel wall with proliferation of the intima and reduction in the caliber of the vessel. There is also a perivascular proliferation of connective tissue. The changes that have been described are found in direct proportion to the severity of the syphilitic infection. In infants dying *in utero* or shortly after birth they are frequent. In those with a mild infection, the lesions may be slight or absent. Large gummata are unusual at any time.

Later in childhood, syphilis of the brain is not very uncommon. The lesions are chiefly the result of the vascular changes and consist in localized or diffuse sclerosis with greater or less atrophy of the convolutions. The lesions of juvenile paresis and tabes do not differ essentially from those that are the result of acquired syphilis. Paresis is very uncommon in congenital syphilis and juvenile tabes is extremely rare.

*Circulatory System.*—The heart and vessels are rarely affected. In stillborn babies, or in those living for a short time with extensive lesions, there may be epicardial or subendocardial infiltrations with mononuclear cells. Still more uncommon is an interstitial fibrosis with the formation of loose fibrous tissue separating the muscle fibers. Recently we saw at autopsy an extraordinary case in which an enlarged heart was found to contain very extensive diffuse lesions which were slightly yellowish in color, replacing a great deal of the musculature. These on section were found to be widespread, diffuse lesions of the nature of gummata. Many giant cells were present in lesions consisting of mononuclear and epithelioid cells. There was marked new formation of fibrous tissue and quite a number of eosinophile leukocytes. This occurred in a colored child six years of age.



*Digestive System.*—Chronic catarrhal pharyngitis is almost a constant symptom of the early cases. In late syphilis there is occasionally seen superficial or deep ulceration of the pharynx, tonsils, or fauces, which may lead to perforation of the soft or hard palate.

There are no frequent lesions of the stomach or intestines either with early or late syphilis.

In stillborn infants or in those dying within the first few weeks with very extensive lesions, there may be associated changes in the small intestine or colon. These consist of a diffuse thickening and fibrosis of the submucosa with a mononuclear cell infiltration. In the more extensive lesions minute foci of necrosis, the so-called "miliary gummata," may be present. In one or two cases which we have seen in children who have lived for some little time, these lesions were associated with diarrhea. At autopsy in these cases they were visible as diffuse yellowish thickenings extending over 6 to 10 centimeters, in quite localized areas in the intestine. These lesions show in section marked fibrous thickening and cellular infiltration in the submucosa. In one of them the overlying mucosa was in part destroyed and replaced by granulation tissue.

Changes in the pancreas are frequent with severe infections; with mild infections they are usually absent. They consist in a diffuse production of connective tissue, which replaces to a greater or less extent the parenchyma of the organ. In the most extreme cases there may be no glandular tissue remaining. The islands of Langerhans usually escape entirely.

*Thymus.*—Occasionally there are found in syphilis numerous small abscesses in the substance of the thymus gland. They are filled with a purulent material consisting of leukocytes with great numbers of spirochetes. The glandular tissue is also infiltrated with leukocytes. These abscesses of DuBois are very characteristic of syphilis.

*Organs of Special Sense.*—In early syphilis otitis is frequently seen accompanying syphilitic pharyngitis. It rarely becomes chronic. Iritis is relatively rare in children, but it may occur even in intra-uterine life, as shown by the presence of adhesions in newly born children. It is usually seen in infants four or five months old, and is always serious. Choroiditis is common, but optic neuritis and optic-nerve atrophy are both rare at this period.

In late congenital syphilis, lesions of the organs of special sense are both common and characteristic. The most frequent affection of the eyes is interstitial keratitis. Choroiditis is frequently present. Neuroretinitis occurs in a small proportion of cases; both eyes are usually affected and it may go on to optic atrophy and loss of vision. The pathology of the syphilitic deafness of later childhood is not clearly understood.

*Genito-urinary Organs.*—In the newly born, or in infants as late as one month, the kidneys may show evidence of incomplete or delayed development, which occurs in many organs as a result of the syphilitic process. In the kidney this consists in a persistence of the neogenic zone, which in the normal fetus is found just beneath the capsule and in the normal course of development disappears within the first twenty-four hours after birth. In the cases of syphilis this zone is more pronounced than it should be and may persist after birth, even in a full



term child, for as long as three weeks to a month. In section, immature developing glomeruli and tubules are found. A consistent accompaniment of early congenital syphilis is a perivascular round cell infiltration, which may be found throughout the cortex or, when less pronounced, only in the deeper layers of the cortex near the pyramids. Accumulations of mononuclear myeloid cells are seen about the blood vessels; among them megaloblasts and nucleated red cells are usually present. Rarely an interstitial fibrosis is found.

Not infrequently an infant with congenital syphilis shows clinically an acute nephritis. In the cases that we have seen the lesions found at autopsy are those of an acute glomerulonephritis with hemorrhages into the tubules, acute or sub-acute changes in the glomeruli, and the usually associated swelling and colloid droplets in the epithelium of the tubules. This differs in no respect from an ordinary acute glomerulonephritis. As Rich has suggested, in such cases the nephritis is probably of bacterial origin, depending on the presence of secondarily invading streptococci in the mucous membranes of the nasopharynx already affected by congenital syphilitic lesions.

In the newly born an interstitial fibrosis of the testis may be present, and rarely a similar lesion may be found in the adrenal.

*Malformations.*—Fournier was largely responsible for the view that a great variety of malformations, including such things as harelip and cleft palate, were due to congenital syphilis. More recent serological and bacteriological observations have failed to support his teachings.

It was once thought that syphilis could affect the fetus at any time during gestation, and both early and late abortions were laid to this cause. It is now reasonably clear, however, that the fetus is not infected before the middle of pregnancy and that only late abortions are suggestive. With a history of repeated premature births, of stillbirths or of macerated fetuses, one should immediately suspect syphilis.

**Early Symptoms.**—Symptoms are present at birth in living children in only a small number of cases. In such there is usually a severe degree of infection, and the infants do not often live more than a few days. Upon the skin there may be seen an eruption of pustules, papules, or bullae. The bullae are usually upon the soles and palms, but may be found upon other parts of the body. The name "syphilitic pemphigus" is often given to this condition. The bullae are at first small, but may then coalesce and form larger ones two inches or more in diameter. They contain a turbid serum which is sometimes tinged with blood, and sometimes yellow from pus. Pustules, when present, are usually seen upon the face or scalp. The general appearance of these infants is wretched in the extreme. The body is wasted, the skin wrinkled, and temperature subnormal. The spleen is greatly enlarged and often the liver also. Death usually occurs within a few days or a few weeks.

In the great majority of cases the infant appears healthy at birth, and continues so for a variable time before the manifestations of the characteristic symptoms of syphilis. As a rule, the more intense the infection, the earlier the symptoms make their appearance. The early symptoms are generally seen between the second and sixth weeks. If three months pass without evidence of syphilis, the probabilities are that the child will escape manifestations of early syphilis, but it does not follow



that he is not infected and will escape late syphilitic lesions. Miller (Moscow) gives the following statistics of the time of beginning of symptoms in 1000 cases:

<i>Appearance of Symptoms</i>	<i>Cases</i>
During the first week .....	85
During the second week .....	138
During the third week .....	240
During the fourth week .....	177
During the fifth week .....	86
During the sixth week .....	54
During the seventh week .....	50
During the eighth week .....	30
After the eighth week .....	140

Sometimes the constitutional symptoms, such as wasting and cachexia, are noticed before the local ones, but usually this is not the case. Generally the first symptom is the coryza or “snuffles,” which resembles an ordinary cold in the head except that it persists. It is often accompanied by a hoarse cry, indicating that the larynx participates in the process. Soon the eruption makes its appearance, being generally first seen upon the hands, feet, face, and buttocks. Fissures and mucous patches may be seen upon the lips, about the anus, and elsewhere. There is often slight fever, from 99° to 101° F. There may also be observed excessive tenderness



FIG. 185.—A, CONGENITAL SYPHILIS, CHILD ONE MONTH OLD; B, SAME CHILD FIVE DAYS AFTER INJECTION OF ARSPHENAMINE.

and swelling about the shoulders, elbows, wrists, or ankles, due to epiphysitis, which may cause the child to cry from the slightest amount of handling, and the limbs may be moved so little that paralysis is suspected.

In a severe case, as these local symptoms develop, the infant’s general nutrition suffers. He loses steadily in weight, he becomes extremely anemic and whines and frets almost continually, but especially at night. The features have a pitiful, drawn expression; the face is wrinkled, giving the infant a very old appearance. The skin has a peculiar sallow color, which has been well described as *café au lait*. The symptoms may continue until a condition of extreme marasmus is reached,



or death may occur from some intercurrent affection of the lungs or digestive organs.

In the milder forms of infection the severe constitutional symptoms described are not seen, although the local evidences of disease are well marked. It is remarkable to see how well some children with extensive evidences of syphilis thrive, provided they were full term infants and are breast fed.

The most important local symptoms are the coryza, eruption, fissures about the mouth and anus, mucous patches, painful swellings at the extremities of the long bones, pseudoparalysis, and onychia.



FIG. 186.—ERUPTION OF EARLY SYPHILIS.

*Rhinitis* is one of the earliest and most constant symptoms of congenital syphilis. It usually begins between the third and sixth week of life, rarely later than the third month. Starting like an ordinary catarrh, it is distinguished by its severity and its persistence. Sneezing, however, ordinarily fails to occur. There is a copious mucopurulent discharge, often tinged with blood. Thick crusts form, which produce the usual symptoms of nasal obstruction; there is great difficulty in nursing; the infant breathes through the mouth, and the mucous membrane of the mouth is dry, causing great discomfort; the upper lip is often excoriated, and mucous patches may form at the mucocutaneous junction. If untreated, the process, which at first involves the mucous membrane only, may extend to the submucous tissue, causing ulceration; but the cartilages and the bones of the nasal fossae are not involved till a later period in the disease.





FIG. 187.—SYPHILITIC SCALING OF THE FOOT IN INFANT EIGHT WEEKS OLD.

The nasal catarrh may be associated with more or less laryngitis, causing hoarseness or aphonia, and rarely there may be laryngeal stenosis. Dillon Brown has reported one case in an infant six weeks old, who recovered after intubation.

*Eruption.*—The early eruption usually appears after the coryza has lasted about a week; but the two may come at the same time; or the coryza may be absent or so slight that the rash seems to be the first symptom.

Occasionally there is seen a diffuse blush or roseola, but usually the eruption is maculopapular, occurring in small, dark red spots about the size of the infant's fingernails. The spots are usually circular and only slightly elevated; a circinate eruption is not uncommon, particularly in Negroes. There is no surrounding inflammation, and no itching. It is usually most abundant about the back, the buttocks and the posterior surface of the thighs. Next in frequency it involves the center of the face, the extensor surfaces of the upper and lower extremities and especially the hands and feet. It may extend over the entire body, but is generally absent over the chest and abdomen. At

first the color is bright, but gradually becomes of a dusky red or coppery hue. After a little time very fine scales may be seen upon the surface of the red macules. The rash comes out slowly, usually requiring from one to three weeks for its full development. It fades gradually, leaving a discoloration of the skin which continues for a long time. The duration of the eruption is from three to eight weeks, less if active treatment is employed.

A macular eruption is rarely seen alone, but is usually associated with the papular variety. The papules are of a brownish color and are hard. A squamous eruption is frequently seen upon the palms and soles, but not often elsewhere. In a few cases this scaliness forms the most distinctive feature of the cutaneous lesion.

*Fissures and Mucous Patches.*—These are not common but are among the most diagnostic features of early congenital syphilis. Fissures are most frequently seen on the lips and at the anus, but they may occur about the nostrils and occasionally elsewhere. The fissures of the lips are really linear ulcers, and are distinguished by their persistence in spite of local



FIG. 188.—SYPHILITIC RHAGADES IN INFANT THREE AND A HALF MONTHS OLD.



treatment. They are multiple, deep, painful, and bleed easily. After healing, these fissures may leave many cicatrices, or rhagades, radiating from the mouth, the contraction of which produces the so-called "purse string" deformity (Fig. 188). Mucous patches may develop from fissures. They may be present upon any of the mucous membranes, frequently in the mouth or on the genitals; they are seldom symmetrical, and while they may be broad they are never deep.

*Condylomata*.—These are formed from papules which are situated in regions where they are exposed to constant moisture and friction. They are common wherever the skin is especially thin, and are most apt to be seen about the anus, scrotum, and vulva; they may also be found behind the ears, between the toes, in the folds of the groin, axillae, or buttocks. They vary from an eighth to half an inch in diameter, are whitish in color, and are raised rather than excavated.



FIG. 189.—A LATER FORM OF ERUPTION IN CONGENITAL SYPHILIS IN INFANT EIGHT MONTHS OLD.

*Hemorrhages*.—These are generally associated with the lesions of the mucous membranes, especially of the nose. In young infants with severe infection, bleeding may occur from the bullous eruption upon the skin, or from the fissures at any of the orifices, particularly the mouth and anus. Fischl has reported 7 cases of multiple hemorrhages in the newly born, associated with other symptoms of congenital syphilis. Mracek noted hemorrhages in 53 per cent of 160 autopsies on syphilitic stillborn infants or those dying soon after birth. Examination of the blood vessels in some of these cases showed infiltration of their walls and narrowing of their lumen. Hemorrhages due to syphilis usually develop somewhat later than those due to hemorrhagic disease of the newly born. Multiple hemorrhages occurring after the first week are usually syphilitic in origin.

*Ectodermal Changes*.—The nails present several peculiarities in syphilitic infants. There may be disease of the matrix resulting in suppuration and exfoliation of the nail; frequently the dorsum is much arched, and the nail appears as if it had been pinched by a pair of forceps—*i. e.*, claw-shaped; this is an early symptom of some diagnostic importance. It is usually more pronounced upon the fourth and fifth digits. The hair and eyebrows frequently fall out completely. This symptom is not usually present in very early infancy.

*Epiphysitis*.—A pseudoparalysis due to syphilitic epiphysitis may be the first symptom of congenital syphilis to attract attention. It is usually noticed when the



infant is a few weeks old that one or more extremities, usually the arm, is not moved, and that passive motion is painful. A history will usually be obtained that the loss of power did not exist at birth but developed subsequently. If the arm is affected it is frequently held in the position characteristic of Erb's palsy. There is tenderness on pressure, and fusiform swelling may be seen about the joints. If the bone affected is superficially situated, as the lower epiphysis of the humerus, radius, or tibia, swelling is very apparent, while it may be scarcely perceptible at the upper epiphysis of the humerus. Separation of the epiphysis may take place,

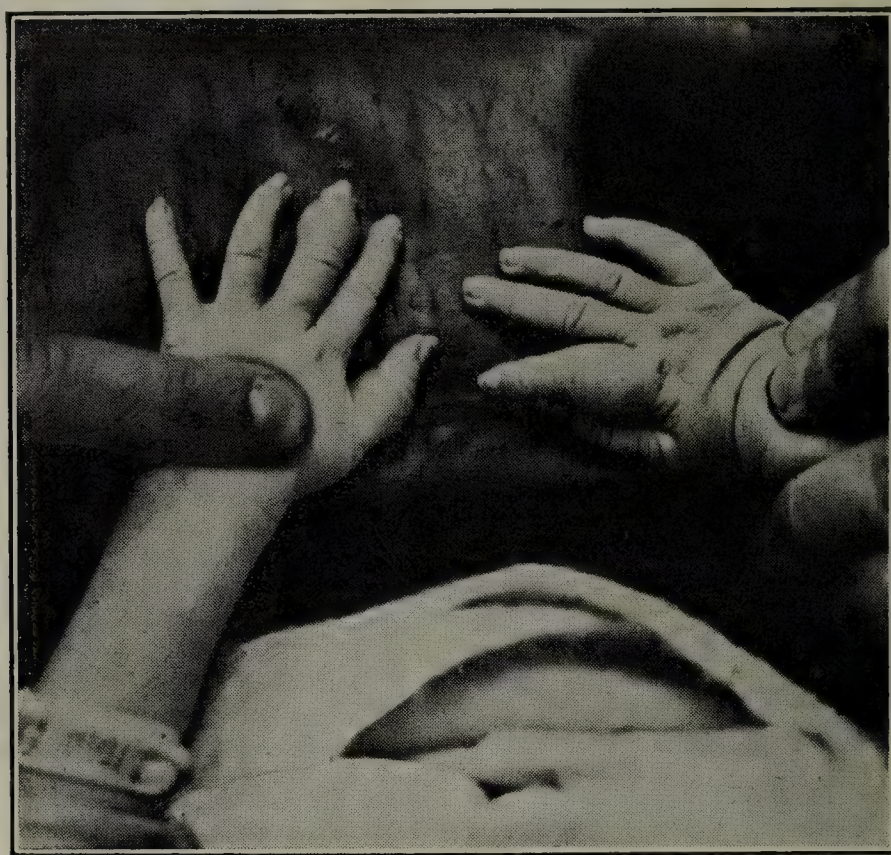


FIG. 190.—SYPHILITIC DACTYLITIS.

On the right hand, first phalanges of forefinger and little finger affected; on the left hand, first phalanx of thumb, and second phalanx of second finger.

so that crepitus is obtained by moving the limb. With this there is sometimes suppuration due to secondary infection. The x-ray is of much assistance in diagnosis.

In the milder cases, or those which have been subjected to active treatment, both the swelling and the tenderness subside rapidly without suppuration; and even though the epiphysis has separated from the shaft, it speedily unites. When pseudo-paralysis has been the chief symptom, very rapid improvement occurs under treatment, and usually there is complete recovery of function in a few weeks.

*Syphilitic Dactylitis*.—This is found in infants usually between the third and seventh months. It is not a frequent manifestation of syphilis. When present there are usually other evidences of bone syphilis, such as periosteal swellings, for the dactylitis is an osteoperiostitis, but usually differs from that affecting other bones in that the involvement of the bone, even at this early age, is considerable and the periostitis rather slight. The symptoms closely resemble the tuberculous form. The enlargement is spindle-shaped, involving the entire phalanx. It is usually not painful. It slowly increases in size and but rarely goes on to suppuration or necrosis. The disease may be arrested and cured by specific treatment. Syphilitic osteo-



chondritis and periostitis are, as has been mentioned, the most common manifestations of syphilis, but they rarely give symptoms and are therefore not detected except by x-ray.

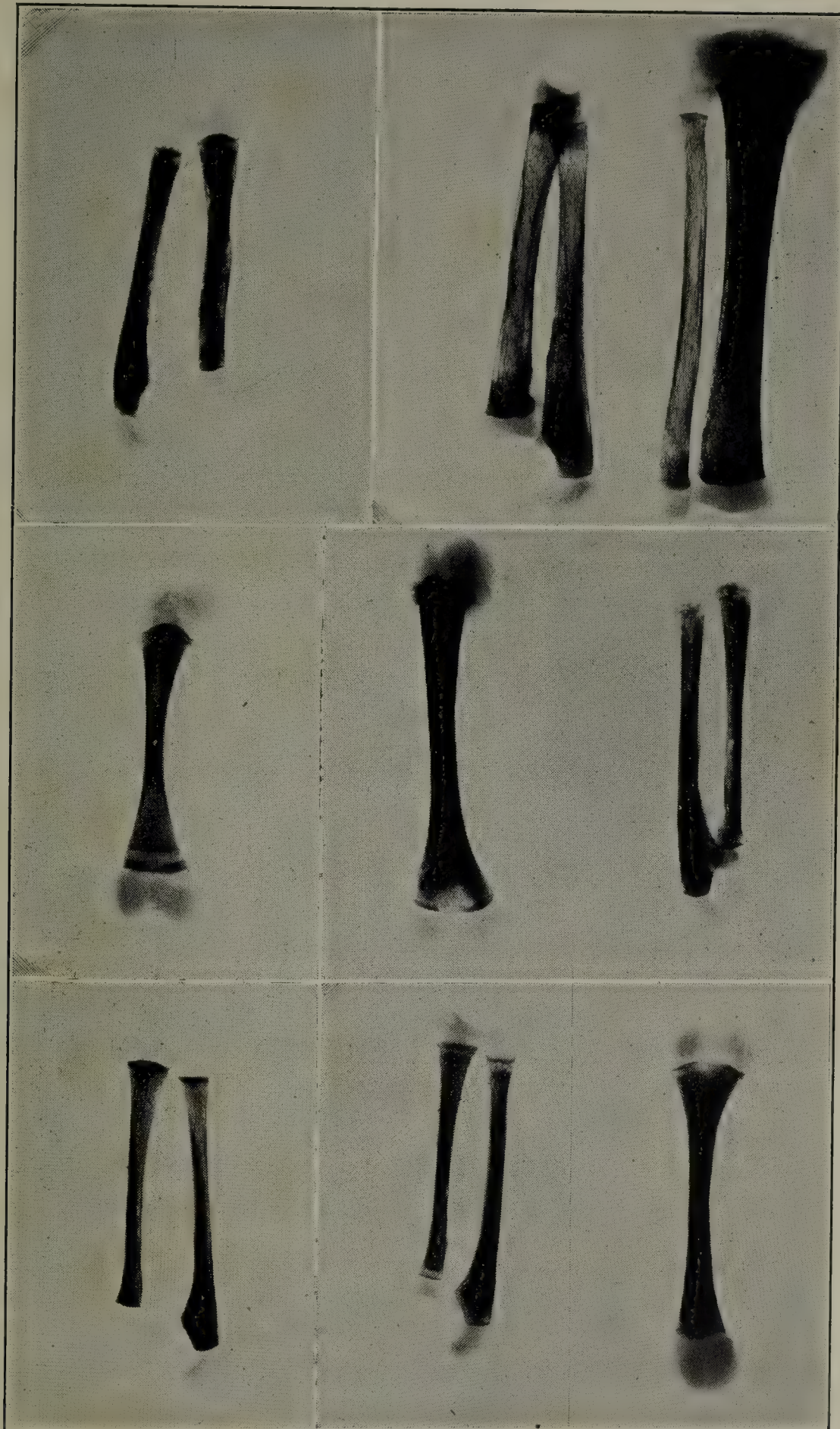


FIG. 191.—ROENTGENOGRAPHIC CHANGES IN THE LONG BONES IN EARLY CONGENITAL SYPHILIS.

*X-ray Appearances of the Bones.*—When symptoms of syphilis are present, bone changes can regularly be demonstrated. Frequently they are the only evidences of the disease. It is uncommon for a single bone to be affected; the lesions are almost always multiple.



In the first three months of life, the most constant change consists in broadening and increase in density of the epiphyseal line. This may be so striking as to be apparent at once or it may require experience to detect it. The changes are especially evident at the wrists and ankles, elbows and knees. Even the proximal extremities of the phalanges may be affected. The epiphyseal line may be smooth or serrated. Equally characteristic, and of even earlier occurrence, is an area of rarefaction beneath the epiphyseal line. This may be regular or irregular, wide or narrow. Scurvy may give a somewhat similar picture, but the age of the patient will usually make the differentiation easy.



FIG. 192.—ROENTGEN-RAY IN  
SYPHILITIC DACTYLITIS.

The zone of rarefaction in scurvy is generally narrow and regular, and there are other identifying characteristics. Irregular moth-eaten areas near the ends of the bones should always suggest syphilis. Areas of cortical thickening due to syphilitic osteoperiostitis are readily made out; they are usually multiple and involve the large bones of the extremities almost exclusively. Their differentiation from the periosteal shadows found in rickets has been discussed above.

Osteochondritic changes characteristically disappear by about the fourth or fifth month of life. This improvement in x-ray appearances takes place even in the absence of specific antiluetic therapy. Areas of rarefaction, involving cortex as well as trabecular bone and brought about by the presence of luetic granulation tissue, may persist in the shaft; but they no longer adjoin the zone of provisional calcifi-

cation; and in time they too disappear, though traces may be found by x-ray for several months. From the age of about six months to two years the most conspicuous x-ray change in the long bones of syphilitic infants is periosteal thickening, especially when there is coincident rickets. Even long after syphilitic periostitis has ceased to be an active process and to cause thickening of the cortex, it may leave a characteristic residuum in the abnormal width of the shafts, particularly in their mid-portion. In such a patient the tibia, for example, may be almost as wide in the middle as it is at the epiphyses. The bones of the skull are sometimes thickened by a similar process of periosteal overproduction of new bone; it is most conspicuous in the parietal bones, but may be seen in the frontals and occipital as well (Parrot's nodes; hot-cross-bun skull). Here, too, the extraordinary deformity seen in some of the most marked cases probably depends upon association with rickets. When there is dactylitis, not only are several phalanges involved but a number of metacarpal and metatarsal bones as well. The phalanges are much thicker and of denser structure than the normal (Fig. 192). Toward the end of the second year, even these changes disappear with further growth. Later in childhood there may be localized periosteal thickening, as described below.



*Lymph Nodes.*—These are often palpable, although marked enlargement is uncommon. No aid in diagnosis can be obtained from any but the epitrochlear glands. If these are considerably enlarged in infancy without evident adequate explanation, a suspicion of syphilis should always be aroused. They may be at times almost the only evidences of the disease.

*Neurosyphilis.*—It is now appreciated that evidences of involvement of the central nervous system in early hereditary syphilis are very frequent. Jeans, especially, has emphasized this. There is found an increase in cells, seldom more than 75 and usually 15 to 30, with a moderate increase in globulin and a positive colloidal gold or mastic reaction. A positive Wassermann reaction may be obtained with the cerebrospinal fluid in about one-third of the cases. In the great majority of instances the pathological changes in the spinal fluid are transitory and clear up without any treatment. Their frequency is not appreciated unless routine lumbar punctures are made at the time when early syphilitic manifestations appear. Clinical evidences of involvement of the central nervous system may be detected at times. Convulsions are not infrequent. There may be a bulging fontanel, opisthotonos or merely stiffness of the neck with a positive Kernig's sign, symptoms suggestive of meningitis but accompanied by no febrile reaction. Rarely the head increases in size and other symptoms of hydrocephalus appear. For these patients early and intensive treatment is imperative.

*Special Senses.*—Evidences of choroiditis are quite common. There are usually small yellowish-red areas with many fine specks of black pigment scattered throughout the retina. They are seen about the optic nerve and increase in number toward the periphery, or are seen only in the latter situation. The optic nerve is usually normal and vision is not affected at this age. The otitis of early syphilis has no distinctive features.

The only visceral symptoms of importance are enlargement of the spleen, which is almost invariably present in the active stage of congenital syphilis, and jaundice with or without enlargement of the liver. Syphilis is one of the causes of prolonged jaundice in young infants and should always be thought of in this connection.

A very characteristic feature of infants with congenital syphilis is the *facies*. Experienced observers can often detect syphilis from the features alone, but it is difficult to analyze just what it is that gives them a characteristic look. A somewhat broad forehead, an unusual prominence of the eyes and scanty eyebrows have been mentioned, yet none of these is constantly present.

*Late Symptoms.*—Fresh symptoms may come on at any period during childhood or about the time of puberty, but rarely at a later time than this. They are seen both in those who have had the usual symptoms of congenital syphilis in early infancy, and in others where the most careful examination into the history fails to disclose any symptoms whatever of early syphilis. It is fair to assume in such cases either that early symptoms were absent or that they were of trivial importance.

Late congenital syphilis shows itself by symptoms which in acquired disease would be classed as tertiary. The most characteristic are the affections of the teeth, the bones, the eyes, gummatous deposits in the solid viscera, the skin or the mucous membranes, the breaking down of which may lead to ulceration, and, finally, symptoms of disease of the nervous system.



*Teeth.*—There are no peculiarities in the first teeth of syphilitic children except their proneness to early decay. They are rather more likely to appear early than late.

The characteristic teeth of syphilis are those of the second set. In estimating the diagnostic value of these changes, only the upper central incisors are to be relied upon; these are the test teeth. Although changes are frequently seen in other teeth, they are not always diagnostic. Typical syphilitic teeth, according to Hutchinson, have each a single notch in the center of the edge (Fig. 193). The notch is usually shallow and more or less crescentic in shape. The enamel is generally deficient in the



FIG. 193.—CHARACTERISTIC TEETH OF LATE CONGENITAL SYPHILIS.

center of the notch, and the tooth here is apt to be discolored. The teeth in other cases are variously dwarfed and deformed. They often taper regularly from the base to the edge, giving rise to the term “screw-driver teeth.” The teeth often are not so flat as the normal incisors, but may be rounded and peg-like. They are not properly placed, but incline either toward or away from each other. They are seldom large enough to touch the adjacent teeth on both sides.

Another deformity sometimes seen in late congenital syphilis affects the molars; their cusps are rounded and present a “raspberry” or “mulberry” appearance. This condition was first described by Moon and still bears his name.

Although Hutchinson’s teeth may generally be taken as conclusive evidence of syphilis, and we have never seen them in any other condition, it is claimed that they are not invariably so. It is to be remembered in this connection that the absence of changes in the teeth is of no importance whatever as evidence that syphilis is not present. These changes are not very common.

*Bones.*—The form of disease which is usually seen at this period is an osteoperiostitis, affecting principally the shaft of the long bones and the cranium. Chronic osteoperiostitis is more frequent after the third year, and most of the cases occur between the fifth and fourteenth years. The most common seat of disease is the tibia, and next to this the bones of the forearm and the cranium. The following is the frequency with which the different bones were affected in the series of cases reported by Fournier: tibia in 91 cases, ulna in 22, radius in 15, cranium in 16, humerus in 12, all others in 37. The process may result either in a diffuse or a localized hyperplasia of bone or in necrosis.

The typical changes are seen in the tibia. The shaft of the bone is principally or solely affected. There is often produced a very characteristic deformity, consisting of a forward curve of the anterior border of the tibia, which has been compared to a saber blade. In some cases the bone is bent inward at its lower third, resembling somewhat a rachitic curvature. Sometimes the entire shaft of the bone is affected, and it may be greatly enlarged. At other times the swelling is chiefly near the epiphysis, where large bosses may form of sufficient size to interfere with the functions of the joint. Instead of affecting the bone uniformly, the disease often affects



only certain parts, leading to the formation of exostoses, which are more likely to be followed by necrosis than are the other lesions. In most of the cases the process is purely a hyperplastic one, leaving the bone permanently enlarged and the limb often lengthened. Less frequently, there occur gummatous lesions in or beneath the periosteum, which may soften, suppurate, and lead to superficial necrosis, with the formation of sinuses that remain open until the sequestrum is exfoliated. Gummata sometimes develop in the interior of the bones, generally near the articular ends; these may soften and break down with abscesses and sinus formation, very much after the manner of a tuberculous inflammation.



FIG. 194.—SYPHILITIC OSTEOPERIOSTITIS OF THE LEFT TIBIA.  
Patient eight years old. The right tibia is normal.

The lesions of the other bones are essentially the same as those of the tibia. They are nearly always symmetrical and often multiple. The course of syphilitic osteoperiostitis is very chronic, and some permanent deformity is the rule, unless cases come early under treatment. With the x-ray the bones are made out to be not only thicker and variously deformed but much denser than normal (Fig. 194). Gummata sometimes appear as rounded excavations in the bones, especially where the formation of new tissue is most marked.

The symptoms are pain, tenderness and deformity. These come on very gradually, and often the deformity is noticed before either pain or tenderness is sufficiently marked to attract attention. The pain is regularly worse at night, and often felt only at that time; it may be mild and occasional, or so severe as virtually to prevent sleep. There is tenderness on pressure over the bones affected, the acuteness of which will depend upon the activity of the process. When suppuration occurs, it appears slowly, and never with symptoms of acute inflammation. Sinuses usually



continue to discharge until a sequestrum is exfoliated. The course of the disease is very tedious, and the whole duration is usually several years.

Syphilitic disease of the long bones is recognized by the nocturnal pain, the tenderness and peculiar deformity, and by the association of other late manifestations of syphilis—the peculiar notched teeth, the interstitial keratitis, the enlarged epitrochlear glands, etc. Tuberculous disease generally affects the articular ends of the bones; syphilis, nearly always the shaft. The diffuse hyperplasia of the tibia and the saberlike deformity of its anterior border are rarely, if ever, due to any other cause than syphilis. The deformities of the long bones have in some cases a certain resemblance to those due to rickets, but the two conditions can hardly be confused if a careful examination is made.

When affecting the bones of the cranium the disease usually takes the form of a gummatous periostitis, which leads to the formation of exostoses. They are from one to two inches in diameter, and project from  $\frac{1}{8}$  to  $\frac{1}{4}$  inch above the general outline of the skull. These may remain as permanent deformities, or they may break down. There may be pain, tenderness, softening, and suppuration, with necrosis of one or both tables of the skull. This may be followed by inflammation of the dura, the pia, and even of the brain itself.

It is rare that inflammation of the bones of the cranium is due in childhood to any other cause than syphilis or tuberculosis, and if the latter can be excluded syphilis may usually be assumed to exist provided traumatism can be excluded. The bosses upon the cranium in rickets are always large, smooth, and regular in position, and belong to infancy. The lesions of xanthomatosis have often been mistaken for syphilis.

*Arthritis.*—This may occur in a subacute or even acute form. It is most common in the knee, though any of the large joints may be involved. The lesion is chiefly synovial. The onset may be sudden with pain and marked tenderness, though it may be painless and develop insidiously. Effusion into the joint occurs and there is local heat and often a rise in temperature to  $101^{\circ}$  F. or more. The process usually remains limited to one or both knee joints and resists obstinately all methods of treatment except antisymphilitic treatment, to which it readily yields. Other symptoms of syphilis are almost invariably present, particularly interstitial keratitis.

*Lymph Nodes.*—These are less frequently affected than in adults. In most cases there may be found a moderate degree of enlargement of the postcervical and epitrochlear glands, swelling of the latter having considerable diagnostic value. Under normal conditions these can scarcely be felt; but in syphilitic children they may be as large as a pea or a small bean; sometimes two or three can be distinguished. Provided no local cause for the swelling exists, they should always create a suspicion of syphilis. The postcervical glands are frequently affected, but are not so diagnostic. The degree of enlargement is rarely great. Occasionally there are seen in the neck large masses of swollen lymph glands which resemble tuberculous swellings. They are, however, very rare.

*Special Senses.*—Most of the ocular changes in late syphilis have been already described with the lesions. The most characteristic is interstitial keratitis, the close connection of which with hereditary syphilis was first pointed out by Hutchinson. Both eyes are usually affected, and in all degrees of severity, from a slight haziness



of the cornea to complete opacity. However, with an early diagnosis and prompt treatment, a marked degree of improvement may be expected in most cases. Choroiditis is frequently, and neuroretinitis rarely, found on ophthalmoscopic examination.

A form of deafness occurs in older children, which Hutchinson states is almost invariably due to syphilis. Its onset is quite sudden, without pain. The loss of hearing is apt to be permanent.

*Skin.*—The most important of the later manifestations of syphilis consists in the formation of subcutaneous gummata. In the early stage they are indurated, elastic, of a grayish color, with red borders. Under treatment they disappear rapidly by absorption; but when neglected they break down, leaving large deep ulcers. These ulcers are quite characteristic in appearance, but may be confounded with those due to tuberculosis. The syphilitic ulcer has rounded, thickened, indurated borders, which, however, are smooth and regular, and a base which is considerably depressed; it has a punched out appearance. It is sometimes covered by hard crusts and is surrounded by a red areola. It leaves a smooth white scar. The most frequent situation is upon the face and upper part of the legs or thighs. It is often over the tibia. Tuberculous ulcers have usually soft, undermined edges; they do not extend so deeply; they are more irregular in outline; the cicatrix left is of a purplish color, which becomes red and slowly fades; tubercle bacilli may be found.

*Nose and Palate.*—Disease of these parts generally begins as the breaking down of gummatous deposits in the mucous membrane. The nose may in consequence be the seat of a protracted fetid discharge (ozena). Rarely, the disease may take on a destructive form of ulceration which is at times phagedenic, and may cause rapid destruction of the nasal cartilages and bones, perforation of the septum, and occasionally of the floor of the nasal fossae. The lower part of the nose may be sunken from destruction of the septum (Fig. 195) or the bridge may be depressed ("saddle nose" deformity). There may be necrosis of the turbinate bones, the vomer, or the ethmoid. In the most severe forms the nose may be almost destroyed in the course of a few weeks. There may be deep ulceration of the soft palate, leading to perforation. In a young person this is almost invariably due to syphilis. In many particulars these ulcerations of the nose and palate resemble lupus; they are distinguished by the rapidity of their progress, syphilis often doing as much damage in weeks as is done by lupus in years.

*Other Symptoms.*—Syphilitic disease of the larynx and bronchi is rare in childhood. The former may give rise to hoarseness or aphonia and occasionally to stenosis; the latter to a chronic cough and asthmatic attacks. There are no characteristic symptoms belonging to congenital syphilis of the lungs.

The only visceral changes which aid much in diagnosis are those of the liver and spleen. The liver is often enlarged, sometimes to a marked degree, and occasionally there is ascites, but very seldom jaundice. There may be a diffuse cirrhosis or gummatous lesions. Enlargement of the spleen may be found during active syphilitic disease. It is occasionally so swollen as to form an abdominal tumor of considerable size. In one case under our observation, in a boy three years old, the spleen extended 5 inches below the free border of the ribs, quite to the crest of



the ilium. It was associated with moderate enlargement of the liver, as is usually the case.

In addition to the local symptoms of late congenital syphilis enumerated, there may be found retardation of physical and of sex development and at times mental deficiency.

*Paroxysmal hemoglobinuria* is a rare manifestation occurring in late congenital syphilitics who usually have been untreated. Aside from the hemoglobinuria these

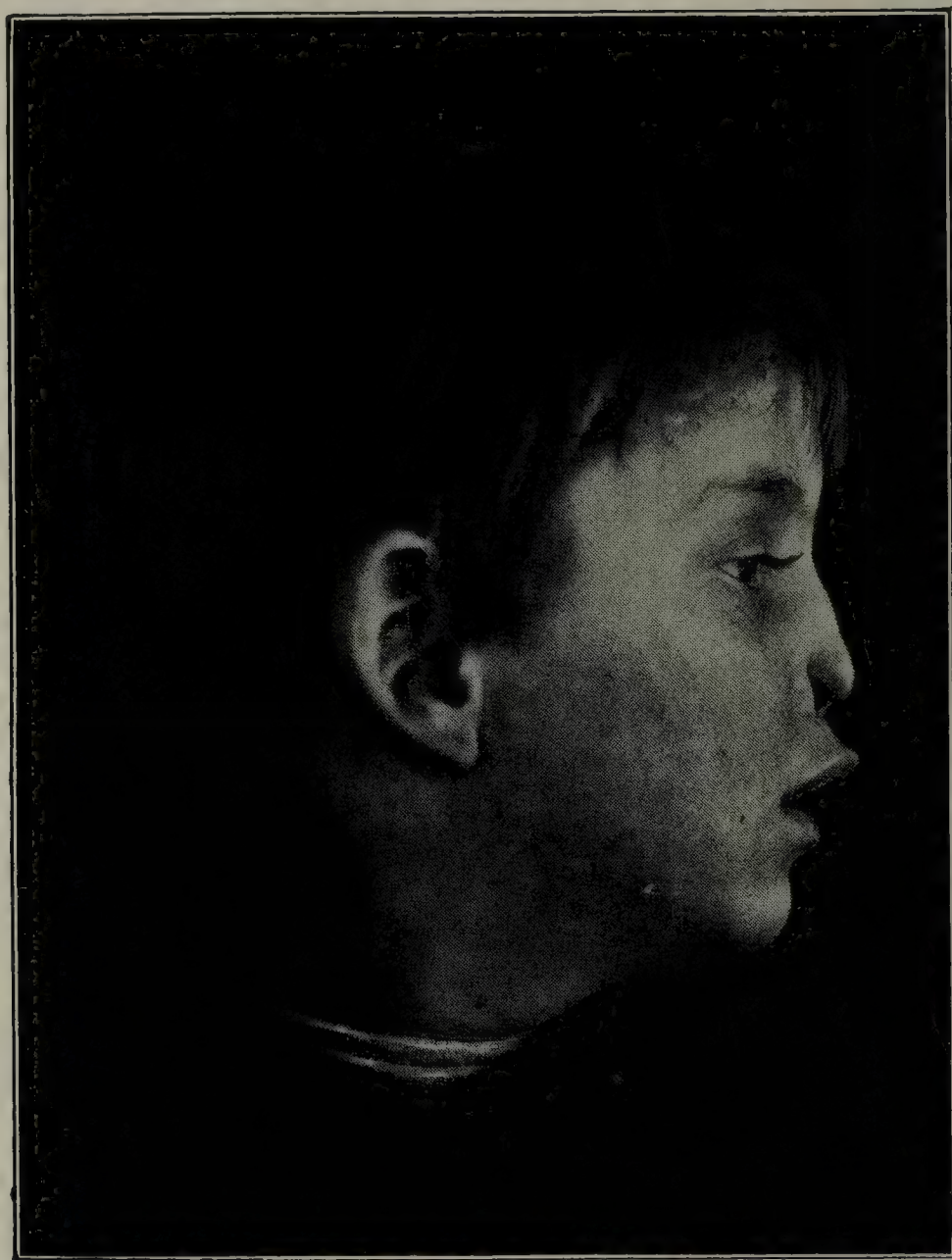


FIG. 195.—NASAL DEFORMITY IN CONGENITAL SYPHILIS; PERFORATION OF THE SEPTUM.  
Boy three and a half years old.

patients rarely show symptoms, but in one of our cases exposure to cold would regularly produce a generalized urticaria as well as hemoglobinuria.

*Neurosyphilis*.—Syphilis of the nervous system may show itself in a great variety of ways. There may be a combination of symptoms giving rise to a more or less distinct clinical picture, indicating diffuse involvement of one or more parts of the brain or cord, or the lesion may apparently be limited to a strikingly small area.

Partial or complete paralysis of one or more extremities or of single nerves, particularly the cranial nerves, is not common. There may be only failure of one or both pupils to react to light, or there may be strabismus. Sudden deafness may occur. There may be a gradually developing optic atrophy.

Acute syphilitic meningitis occasionally occurs; the clinical picture may closely



resemble that of tuberculous meningitis. Mention has been made of syphilis as a cause of hydrocephalus. In our experience this has been unusual. Epileptiform attacks, also, may depend, but in our experience very infrequently, upon syphilis. Statistics vary much as to the rôle of syphilis in producing feeble-mindedness. Studies upon inmates in institutions for the feeble-minded in this country have shown that between 3 and 10 per cent are syphilitic. The association of the two may at times be purely accidental, but there can be no doubt that congenital syphilis is occasionally an important etiological factor. Lesions of the cord due to syphilis are distinctly uncommon.

Juvenile paresis is occasionally seen, but it is rare before the fifth year. There is no doubt of its dependence upon syphilis. The symptoms usually appear shortly before or about the time of puberty. They are quite characteristic. A child that has developed in a practically normal way gradually begins to lose his ability to do certain things. There is loss of memory and a difficulty in speech, which consists in dropping a syllable or a whole word. If he has been able to write, the capacity to do this is gradually lost. Eventually speech is impossible and the intelligence is reduced to a minimum. Walking becomes difficult and later almost impossible. The child loses all sense of cleanliness and remains in a demented condition often for years until death occurs from inanition, bed sores or from intercurrent disease. There is usually loss of reaction of the pupils to light, irregularity of the pupils, and often some degree of optic atrophy. The cerebrospinal fluid contains an excess of cells and globulin, and gives a strongly positive Wassermann reaction with a paretic colloidal gold or mastic curve. The course is progressively downwards, sometimes slowly, sometimes with surprising rapidity.

It is at times difficult to differentiate from juvenile paresis a form of cerebral syphilis, which in our experience is much more common than the paretic form. The history often gives valuable aid, showing that the child has never appeared entirely normal. There has usually been, almost from the beginning, some, often a marked, degree of mental impairment, and speech has been slowly and imperfectly acquired. The children are oftentimes restless and disobedient. They may have screaming attacks. The reflexes may be exaggerated or absent. Attacks of headache and vertigo with vomiting are not uncommon. There may be unequal pupils or failure to react to light. Some degree of optic atrophy is generally present. Hemiplegic attacks may occur in the course of the disease or they may appear as the first evidence of cerebral involvement. These attacks may occur first on one side and then on the other, and the paralysis often improves to a marked degree, even without treatment. With this form of cerebral syphilis there is not the same tendency to mental and physical deterioration as with paresis. The children may live many years in about the same mental condition. Sometimes with treatment, especially if it is begun early, considerable improvement occurs. The cerebrospinal fluid shows in these cases also an excess of cells and globulin and always gives a strongly positive Wassermann reaction. As is the case with paresis, it is exceedingly difficult to diminish the intensity of or to abolish the Wassermann reaction in the spinal fluid by anti-syphilitic treatment of any kind, no matter how vigorously given or how often repeated. The same may be said of the colloidal gold or mastic curve.

Tabes may be found in childhood as the result of congenital syphilis but is very



uncommon. The symptoms are similar to those of the adult form of the disease, but some of them may be absent. The Argyll Robertson pupil is constant, but the patellar reflexes may not be lost and Romberg's symptom may not be marked. Incontinence of urine is frequent. The course of the disease is exceedingly slow. It may last for fifteen or twenty years or even more.

**Diagnosis.**—The diagnosis of florid early syphilis in most cases is not difficult. The coryza, eruption, labial fissures, mucous patches about the anus and genitals, enlarged spleen, and later the general cachexia—all unite to form a picture which it is difficult to mistake. Special care should be taken not to confound the moist papules of simple intertrigo upon the buttock or thighs with those of syphilis. Much assistance may be obtained from the discovery of the spirochetes in the external lesions. This is a means of diagnosis which is too seldom employed. The dark field is useful but not essential. They can be demonstrated by the India ink method.

The Wassermann reaction is of great value in children over three months of age. Before this time the findings are not conclusive. During the early months it may be quite negative in typical cases, although it is frequently positive in cases with outspoken symptoms. A positive reaction after the age of two weeks indicates that syphilis is present. Before this time it is not an uncommon experience when the mother has received treatment during pregnancy to have the child's blood positive, whereas later on it may be constantly negative and no symptoms of syphilis may ever appear. The Kahn test and other flocculation reactions give essentially the same information as does the Wassermann test.

In recent years, with the more general treatment of pregnant mothers, the proportion of our syphilitic patients with florid lesions has been steadily diminishing. The average case rarely exhibits more than coryza and a slight eruption on the back, buttocks or thighs. Many show no symptoms whatever. The chief diagnostic problems of late have been to decide in the absence of symptoms whether syphilis was or was not present. One's chief dependence here is upon x-rays of the bones and serological tests.

In a number of instances the infants of mothers who have been intensively treated during pregnancy have shown mild but characteristic syphilitic bone lesions by x-ray, but have had negative Wassermann and Kahn reactions persisting for more than six months. The importance and implications of these contradictory findings are still obscure.

In late syphilis the following symptoms are the most reliable for diagnosis: notching of the teeth, falling in of the bridge of the nose, interstitial keratitis, deafness not traceable to ordinary otitis, enlargement of the spleen and epitrochlear glands, ulceration of the palate or nose, the saber-like deformity of the tibia, and exostoses upon the tibia or cranium. There are often found in older children indefinite symptoms in regard to which a suspicion of syphilis exists. For such cases the Wassermann test is of very great value but occasionally it may give a negative reaction.

It becomes at times important to distinguish congenital from acquired syphilis. Visceral lesions in acquired syphilis are not common and belong to the late period of the disease; in the congenital form they are well-nigh constant and occur early,



often being present at birth. The acute epiphysitis, sometimes accompanied by pseudoparalysis, seldom if ever occurs in acquired syphilis, but is almost constant in the congenital form. Symptoms due to defects in development, like the misshapen fingernails and Hutchinson's teeth, are seen only in congenital syphilis. The early symptoms referable to the mucous membranes and mucocutaneous surfaces—coryza, hoarseness, hemorrhages, labial fissures, etc.—so characteristic of congenital syphilis, have no place in the acquired form, while the single primary lesion sometimes found in the acquired form does not exist in the congenital disease.

**Prognosis.**—Generally speaking, the prognosis is worse in infantile syphilis than in that of adults. In infancy it is much worse when congenital than when acquired, for the reason that the child who is the subject of congenital syphilis has been affected early in his existence, and this has modified his entire development. As far as a cure of the disease is concerned, the prognosis in late congenital syphilis is less favorable than when treatment is commenced early in infancy; but with florid syphilis in young infants the mortality is high.

The prognosis in an individual case depends upon whether the mother has been treated during her pregnancy, upon the age at which the symptoms develop, the time when treatment is begun, upon its thoroughness, and upon the surroundings and mode of nourishment of the child. The outlook is better the longer after birth the first symptoms appear; it is also very much better in infants who are nursed than in those who are artificially fed.

As compared with syphilis of the adult, relapses are less frequent, and when they occur early they are nearly always the result of insufficient treatment. If proper treatment is carried out, these severe late symptoms are not common. We must conclude that treatment persisted in only for a short time and not energetic enough to influence in any way the Wassermann reaction has, nevertheless, a great influence in preventing the further ravages of the disease. We have observed children after an interval of several years, who had been treated in this unsatisfactory way, and could find no evidence of the disease but a positive Wassermann reaction. It is a fact also that almost all of the patients who apply for treatment for late congenital syphilis have never received any treatment in infancy.

The prognosis is better in the later children of syphilitic parents than in the earlier ones, provided infection has preceded the birth of all the children. This fact illustrates the development of immunity even without treatment.<sup>1</sup>

The prognosis of syphilis of the nervous system should be considered by itself. In early infancy with evidences of neurosyphilis only in the cerebrospinal fluid but with no clinical symptoms, the prognosis is good provided energetic treatment is instituted. When the clinical symptoms, whether meningeal or cerebral, are mild or have existed only a short time, they will in very many instances disappear entirely; but when they have been present for weeks or months, the outlook is bad, as it is with syphilis of the nervous system of older children. Many become and remain mentally defective. In the syphilis of the nervous system of older children, certain of the manifestations such as local paralyses may yield promptly to treatment.

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<sup>1</sup> The following is an instance in point:

In the first pregnancy, the mother aborted with a dead child at the sixth month; in the second, at the seventh month; in the third, at seven and a half months; in the fourth the child was born at term, and lived eighteen days; in the fifth it lived six weeks; in the sixth the child lived four months, without treatment.



It is also reported that many cases of syphilitic epilepsy and hydrocephalus have been greatly improved or cured. Gummatous lesions usually disappear promptly with appropriate treatment as in acquired syphilis. But the lesions of the nervous system are usually the result of arterial disease or of meningitis and encephalitis. These are very little influenced by treatment. In cases of diffuse involvement of the brain and in juvenile paresis, we have not seen lasting benefit from even the most energetic and long-continued treatment.

The question is often raised as to whether congenital syphilis is ever completely curable. Certainly a large number of cases treated promptly and efficiently are rendered symptomatically and serologically negative. We have had several such cases come to autopsy from other causes, in which a careful search for spirochetes and lesions of syphilis proved futile. It seems certain that syphilis is completely curable, but it is impossible to say how frequently. Sometimes after many years a supposedly cured case will relapse and a positive Wassermann reappear.

**Prophylaxis.**—The mother should be treated during her pregnancy: (1) if she is syphilitic, whether the disease was acquired at the time of conception or subsequently; (2) if the father is known to be suffering from syphilis, whether the mother has symptoms or not; (3) if the mother has ever previously shown signs of syphilis and still gives a positive Wassermann reaction, even if she has had no active symptoms for a considerable period. In all these conditions if efficient treatment is carried on throughout pregnancy there is a strong probability, but in no case a certainty, that the child will escape. The third condition mentioned is the one in which treatment is most likely to be neglected, especially if the mother has previously given birth to a child who was not syphilitic. Syphilis, however, shows a strong tendency to reappear and become active during pregnancy, even though it has been long quiescent, as the following case cited by Diday shows:

A woman who had lost seven children from syphilis was put under treatment during the eighth pregnancy; result—child born healthy, and continued so. In the ninth pregnancy treatment was continued with a like result; in the tenth pregnancy, no treatment, child syphilitic, dying when six months old; in the eleventh pregnancy, treatment repeated, child healthy.

Williams has studied carefully the effects of treatment of syphilitic mothers upon the incidence of early syphilis in childhood. Of 169 pregnant women who were not treated, 48 per cent of the children showed early signs of syphilis; of 102 women who were insufficiently treated, 33 per cent; while of 178 women who were well treated only 6.7 per cent of the children showed early signs.

**Treatment.**—It is important to establish the diagnosis of syphilis, either clinically, serologically or by x-ray, before treatment is begun. To begin treatment with no evidence but a doubtful Wassermann reaction may leave one in perpetual doubt as to whether syphilis was present, should a negative reaction be found subsequently. A nonsyphilitic child should not be subjected to antisyphilitic treatment. If there are no evidences definite enough to establish the diagnosis there is no harm in waiting. Children viewed as suspects, either because of syphilis in the parents or doubtful evidence by physical examination or x-ray, should be kept under close observation for at least six months and should have their blood tested



every two months. If there are neither clinical nor roentgenologic evidences and if the Wassermann reaction is negative at six months, one can rule out syphilis with certainty.

Treatment should be begun promptly and pushed vigorously unless the disease is so extensive that such measures would be dangerous to the child, as may be the case with feeble premature infants or those with the most florid syphilis. Dosages should then be reduced to one-half or one-third of the usual amount, and gradually increased if no ill effects are observed. Indications for temporary suspension of treatment are febrile diseases, unexplained loss of weight, or evidences of poisoning from the treatment.

*Drugs.*—Arsenicals are still the cornerstone in the treatment of syphilis. Arsphenamine itself is probably the most effective preparation, but because it can only be given intravenously and because of its extremely irritating effect when accidental extravasations occur, it is little used in children. It is somewhat more troublesome to prepare, since it requires neutralization. The dose is 0.01 gram per kilogram of body weight. The solution should stand for half an hour before use; this is said to lessen the toxicity.

Neoarsphenamine and sulpharsphenamine have the advantage that they can be given intramuscularly, and hence are particularly useful in young infants; it is our practice to use them routinely and not to attempt intravenous therapy under four years of age. The drugs should be given well diluted and the injection made slowly, so that in case of a general reaction it may be stopped. The dose of neoarsphenamine is 0.015 gram per kilogram of body weight and of sulpharsphenamine 0.02 to 0.025 gram per kilogram. The latter preparation is the less irritating locally and appears to be equally satisfactory.

Acetarstone (stovarsol) is an arsenical preparation which may be given by mouth. The initial daily dose should not exceed 5 milligrams per kilogram of body weight, but this may be rapidly increased up to 20 milligrams per kilogram. Our experience with it, though of recent date and therefore limited, has been decidedly encouraging. In a few infants the dose recommended may cause diarrhea.

Bismuth preparations have largely replaced mercury for use between courses of arsenical treatment. In its efficacy bismuth stands between arsenic and mercury. The drug is given in oil, either in the form of tartrate or salicylate, intramuscular injections being made at weekly intervals. To children over six years old, 0.1 gram of either salt may be given; half this quantity to those between two and six and 0.025 gram to those under two years of age.

Mercury has by many been discarded entirely. It is less effective than bismuth and more likely to cause poisoning. In dispensary practice, we employ it between courses of arsenic in patients who live at a distance; in the form of inunctions it can easily be given at home. In the form of mercury ointment, 10 to 15 grains a day may be given in a petrolatum base and rubbed into the skin of the thighs or abdomen. The site should be changed each day to avoid irritation.

Whenever lesions exist that can be classified as tertiary, potassium iodide may be used in combination with the regular forms of treatment. These are generally manifestations of late congenital syphilis, affecting chiefly the skin, the bones and the viscera.



*Plan of Treatment.*—As a general plan of treatment in congenital syphilis the following may be recommended: weekly injections of neoarsphenamine or sulpharsphenamine for six doses, followed by a course of similar length of injections of a bismuth preparation in oil when it is possible to have the patient return for continuous treatment. If this cannot be arranged, the patient may be allowed a six weeks' course of daily inunctions of mercury at home. This program should be repeated until three courses of six weeks each have followed persistently negative serological tests. Wassermann tests should be made at the beginning of each course. If the Wassermann reaction remains positive, treatment should be continued for two years, at the end of which time it is advisable to stop treatment temporarily for six months, and begin again for a period of one year. If no improvement is evident in the blood, it is then advisable to withhold all treatment and to follow the child clinically, beginning again only in the event of clinical manifestations of the disease.

If treatment is satisfactorily completed, Wassermann tests should be taken at three-month intervals for one year and thereafter every six months for an indefinite period. Experience has shown that recurrence of a positive reaction following a satisfactorily completed series of treatments is exceedingly rare.

*Local Treatment.*—Ulcerated lesions of the skin require cleanliness and the application of some mercurial preparation. Mucous patches should be dusted with equal parts of calomel and bismuth subcarbonate and fissures and ulcers of the mucous membranes should be treated with silver nitrate. Phagedenic ulcers, while exceedingly rare, may occur in the nose or palate and should be cauterized with nitric acid or the acid nitrate of mercury.

*Reactions.*—Severe reactions to arsenic in its various forms are uncommon. Nausea and vomiting, or mild nitritoid reactions, should be considered as premonitory signs of possible severe reactions. The dose of the drug should be reduced to one-half, and if symptoms are repeated arsenic should be stopped altogether. Manifestations of arsphenamine poisoning have, in our experience, been rare. The most frequent is a severe hypoplastic anemia, with thrombopenic purpura; transfusion may be required. Occasionally there develops acute yellow atrophy of the liver, giving rise to prolonged intense jaundice. Dermatitis exfoliativa may occur. The experiments of Craven on animals suggest that diet is an important factor in causing arsphenamine poisoning; whether these results are applicable to man is not known. Any manifestation of arsenical poisoning demands discontinuance of all arsenicals for an indefinite period.

The local effects of sulpharsphenamine, bismuth or mercury injections are almost never troublesome when sufficient care has been used in administration. Sterile abscesses occur infrequently and small indurated areas, while more common, usually disappear in the course of several weeks.

The prognosis has already been discussed. In general it may be said that the symptomatic cure of syphilis, except with involvement of the central nervous system, is relatively easy, but it is often difficult to obtain a persistently negative Wassermann reaction. The symptoms of sharply localized neurosyphilis are usually promptly affected by treatment and the symptoms of early meningeal involvement may disappear. Extensive central nervous system syphilis is but little influenced,



though the progress of the disease may sometimes be arrested. Paresis and tabes usually pursue their course uninfluenced by treatment. The Wassermann reaction of the blood sometimes becomes negative but that of the cerebrospinal fluid remains positive, and the symptoms have in our experience been entirely unaffected in almost all cases. Satisfactory results in a few cases have been obtained through the use of malaria and by the Swift-Ellis technic.

The general treatment of syphilis is important and a proper perspective of the child's condition should not be lost sight of during the course of treatment. It is possible that anemia and malnutrition may develop, and under such circumstances it is wise to suspend specific treatment for a time. It should be remembered that syphilis is essentially a chronic disease, and that slower and more prolonged treatment controls the disease with fewer risks to the patient than are obtained with too intensive therapy.

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## CHAPTER CXXXVIII

### RHEUMATIC FEVER

Rheumatic fever is an infectious disease of unknown etiology characterized by the presence of small proliferative focal lesions in various parts of the body and sometimes by acute exudative phenomena. The most striking clinical manifestations are found in the heart, the joints, the subcutaneous tissue and the nervous system, where the disease manifests itself as chorea minor. Our present conception of the manifold nature of the disease is due largely to Cheadle, who was the first to point out clearly the close relation between many conditions formerly not regarded as rheumatic.

**Incidence.**—Rheumatic manifestations are occasionally seen even as early as the first year of life, but they are rare before the fourth year. From then on they are among the most frequent of the diseases of childhood. It has been maintained by Still, Draper and others that the disease shows a predilection for individuals of a certain constitution or body type; red-haired, freckled persons in particular have been mentioned. There is no dispute about the familial incidence; in fully half of the cases a family history is obtainable; contact infection is probably the important factor here. Girls are affected with somewhat greater frequency than boys, the ratio being about 55 to 45. Rheumatism is a disease of urban communities. It is much more common in certain localities; thus in the eastern United States it is found much more frequently in New England and the Middle Atlantic States than in the Southern States. Rheumatic infection is particularly common in the British Isles. It is not possible to explain these variations in incidence by climate alone; in climates as different as those of Canada and Egypt the disease is equally common. Attacks occur at all seasons, but notably in the winter and spring months. Respiratory infections appear to lower resistance to the infectious agent, and the upper respiratory tract is usually regarded as the portal of entry. It is believed that exposure to cold and wet, damp dwellings, lack of sunlight, and rapid changes of weather are all predisposing factors. One attack strongly predisposes to a second and in most cases there is a history of several attacks of greater or less severity. Whether these represent reinfections or recrudescences of a latent infection is not known; the latter hypothesis appears the more likely.

**Etiology.**—Various organisms have been cultivated at one time or another from rheumatic lesions and from the blood stream of patients in an active phase of the disease; they have usually been alpha- or beta-hemolytic streptococci. The results have not been consistent or reproducible, and in general negative cultures have been obtained. It must be admitted that the etiological agent is still undetermined. Swift has advocated the view that the causative agent is not always the same, and that one or another type of streptococcus may be responsible. In support of this conception he finds that patients with rheumatic fever are likely to exhibit skin



hypersensitiveness to filtrates of streptococci, but that the response to the filtrates from particular strains is most variable. Coburn has assembled a mass of evidence implicating various forms of hemolytic streptococci. Allergy is thought by some to play an important part in producing the exudative manifestations of the disease.

**Pathology.**—The lesions of rheumatism are influenced to some extent by the character of the tissue in which they occur. The Aschoff body found in the ventricular myocardium is a small compact submiliary nodule. The lesion found in the wall of the auricle is more diffuse. The subcutaneous fibroid nodule, although retaining many characteristics of the lesions found in the heart, may reach a great size—sometimes 2 or 3 centimeters in diameter. The lesions that have been described in the nervous system in chorea bear little resemblance to other rheumatic manifestations, and are most variable and inconstant. There can be no doubt as to the rheumatic nature of chorea minor, but whether a specific anatomical lesion exists is highly doubtful. It is to be hoped that further studies with recent neuro-histological methods will clear up this question.

*The Heart.*—In some cases only the myocardium is involved, but usually endocarditis is present as well. Pericarditis when it occurs is generally accompanied by marked myocardial and endocardial involvement. The characteristic myocardial lesion—the Aschoff body—is found in the interstitial tissue in close proximity to the smaller blood vessels. There is a central coagulum of fibrin and cellular debris surrounded by large wandering cells of irregular shape, which are often multinucleated and contain a deep-staining finely granular cytoplasm. These cells are merely transformed macrophages. Among them may be found a few lymphocytes and polymorphonuclear leukocytes. Proliferative changes are present about the walls of the smaller blood vessels. In the earliest lesions mononuclear round cells and polymorphonuclear leukocytes predominate; later on the large cells become more prominent. As the lesion becomes older the specific cells disappear, fibroblasts proliferate and eventually only a fibrous scar remains.

MacCallum has described lesions beneath the endocardium of the auricle which differ from the foregoing in that they tend to be less circumscribed, extending for some distance in the subendocardial tissue. This contrast is illustrated in the accompanying plate.

The *acute endocardial lesions* are largely confined to the valves. Coombs gives the following data showing the frequency of involvement of the different valves in 97 cases:

Mitral .....	97
Aortic .....	57
Tricuspid .....	35
Pulmonary .....	2

The acute lesions as seen in the gross consist of minute pinkish-gray warty vegetations which are found along the line of closure. Microscopically these consist of structureless hyaline masses, which are eventually organized and converted into scar tissue. Aschoff bodies are regularly found at the base of the valve; indeed these are present in some early cases in which vegetations have not yet developed, suggesting that the infection starts at the base of the valve. The valvulitis is by no



means confined to vegetations along the line of closure, although the process is usually most intense there. The entire valve leaflet and the associated chordae tendineae often become infiltrated with inflammatory cells; this inflamed tissue eventually undergoes scarring, producing valvular deformities. Microscopically, evidences of the rheumatic process are not infrequent just beneath the mural endocardium. In children, *acute* rheumatic lesions are found in practically every fatal case; Coombs observed them in 87.5 per cent of his cases during the first decade. In most of these there were in addition chronic changes from previous attacks, upon which the fresh lesions were superimposed.

*Chronic Valvular Disease (Valvular Sclerosis).*—In certain cases the valves may undergo such minimal damage that complete restoration of function takes place. Complete clinical recovery sometimes occurs after pronounced cardiac symptoms, and may be due either to healing of valvular lesions or to a pure myocarditis without valvular involvement. Unfortunately such an outcome is infrequent; when involvement of the heart has been sufficiently marked to give clinical symptoms, permanent scarring with valvular deformity is to be expected. The warty vegetations, which at first consist only of fibrin enmeshing various blood cells, gradually become hyalinized and covered with endothelium; organization follows and they eventually heal by scarring. The inflammatory tissue in the substance of the valves likewise heals by fibrosis. Gradually the vegetations disappear, leaving a deformed, thickened valve. This thickening is not confined to the line of closure but may involve the entire leaflet and the chordae tendineae of the auriculoventricular valves, which are then shortened and unable to close properly. The valvular incompetency of early heart disease is not due to any such cause, however, but to dilatation of the valvular ring occasioned by the myocardial damage. It is doubtful if a deposit of vegetations is ever sufficient to interfere with closure.

Valvular sclerosis is a chronic process; cicatricial changes require weeks and months to develop; the extreme deformities of mitral stenosis and aortic stenosis develop only after five to ten years and are hence uncommon in childhood. Probably they are due to repeated insults to the valve; the process of healing of rheumatic lesions is not necessarily slow, for fibroid nodules may disappear entirely in the course of a few weeks. As the result of repeated inflammation, the valves become more and more sclerosed and thickened; adhesions form between the cusps and the end-result is a narrowed orifice which prevents the proper opening of the valve.

The compensatory changes in the heart and circulation in valvular disease and the effects of decompensation are discussed elsewhere.

*Pericarditis.*—Although this is recognized clinically in only a small proportion of rheumatic attacks, some evidence of it is found in more than 90 per cent of children dying with acute carditis. Both layers are affected, but the visceral layer—the epicardium—suffers most. The serous surfaces appear roughened and reddened; in mild cases there may be no increase in the quantity of fluid, although it may become turbid. Large effusions are uncommon; it is rare for the sac to contain as much as 500 c.c. There may be deposits of fibrin, particularly on the auricular appendages. In severe cases exudation of pinkish fibrin may almost obliterate the pericardial cavity; purulent effusions are not found, although leukocytes are commonly present in the exudate. Very exceptionally the fluid may be hemorrhagic.



Microscopically, evidences of subacute inflammation are always found beneath the epicardium; discrete submiliary nodules are occasionally found. As the process subsides, fibroblasts invade the fibrinous exudate and cicatrization commonly occurs, binding the visceral to the parietal pericardium. The adhesions may be intimate or may consist of long strands; they may be localized, but in the more severe cases the entire cavity is obliterated by fibrous tissue.

Inflammations of the pericardium may involve the adjacent pleura and mediastinum. Small areas of dry pleurisy, sometimes accompanied by pleural effusion, are among the rarer manifestations of the disease. Obliteration of the pericardial sac alone may cause no interference with cardiac function, but when extrapericardial adhesions are also present, serious embarrassment may follow because the heart must then pull the chest wall or mediastinum to which it is attached.

*Other Rheumatic Lesions.*—Focal lesions of the Aschoff body type have been described in the pleura and peritoneum; they are commonly present in the periarticular tissue of involved joints; they have been described by Pappenheimer and von Glahn in the wall of larger arteries. The subcutaneous nodule (see Plate V) consists of a mass of fibrous tissue in which are embedded a number of submiliary nodules. The joints ordinarily show merely a nonspecific type of subacute inflammation with desquamation of the synovial membrane. Aschoff bodies are sometimes present beneath the synovial membrane.

**Peculiarities of Rheumatic Infection in Childhood.**—As has already been mentioned rheumatism is rare before the fourth year. In the youngest subjects, the symptoms are usually confined to the heart. Chorea reaches its maximum between the fifth and fifteenth years; young adults rarely exhibit this symptom. Although transient growing pains and mild joint inflammations are seen in children under ten years, it is rare to encounter the red, swollen, painful joints so common in adolescents and young adults. No adequate explanation has been offered for the different age incidence of these various rheumatic symptoms. Although the disease as a whole is slightly more common in females, this does not apply to its individual manifestations. Arthritis is decidedly more common in boys, while chorea is much more frequent in girls.

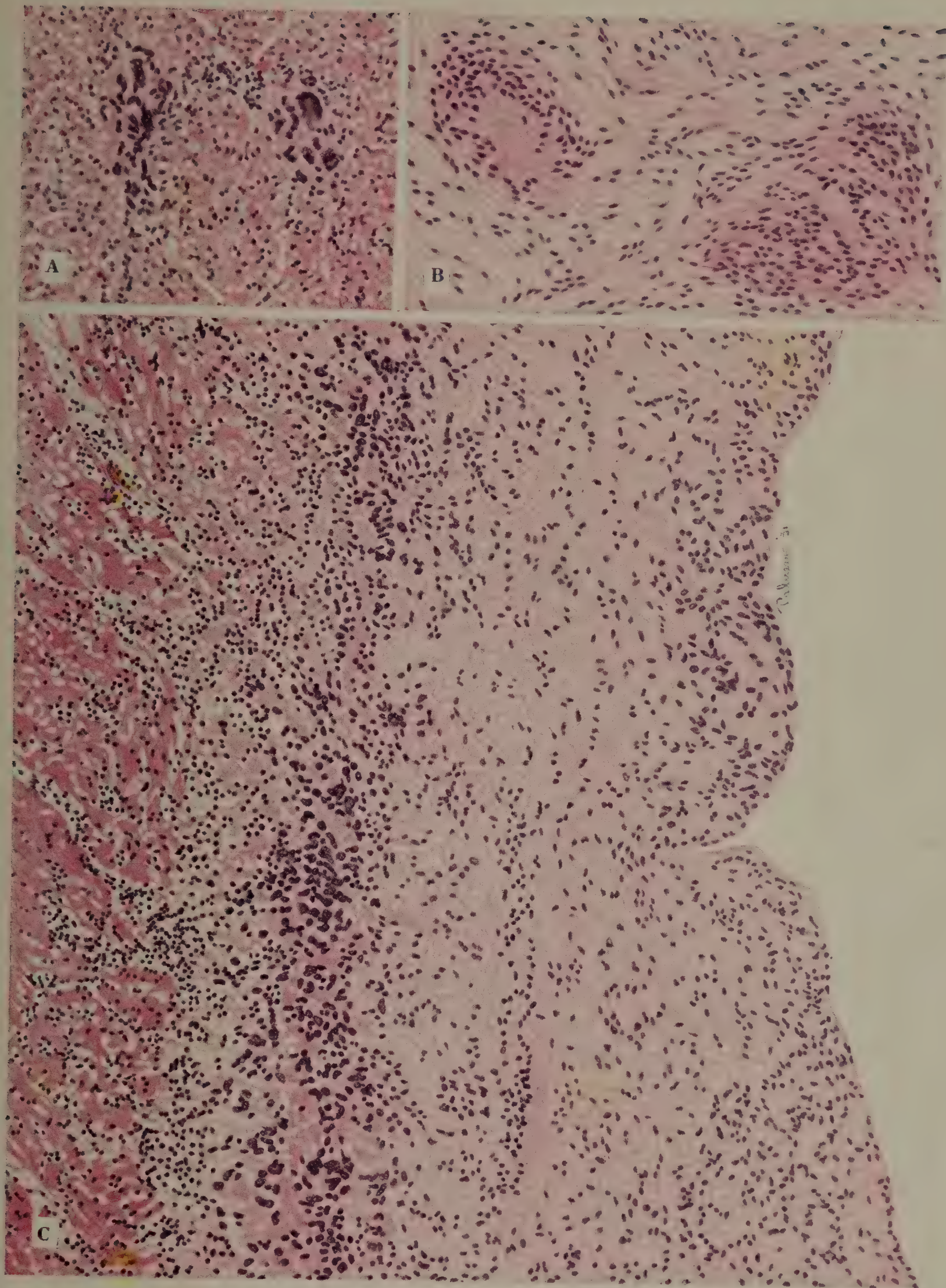
**Relation of Rheumatic Fever to Other Diseases.**—Cases of *subacute bacterial endocarditis* due to the streptococcus viridans are often superimposed upon an old rheumatic endocarditis. It is believed by some that rheumatic fever represents a benign form of infection with this organism, bacterial endocarditis being the malignant form. Such a view cannot be accepted at the present time. There is much evidence against it. The *Streptococcus viridans* does not confine its assaults to rheumatic heart valves; it may attack valves which are the seat of congenital malformations, or, in adults, it may be superimposed upon atheromatous or syphilitic lesions.

*Scarlet fever* is sometimes accompanied by articular symptoms. Coombs, who accepts without question the streptococcal etiology of rheumatic fever, is inclined to regard scarlet fever as a rheumatic manifestation, a view which has found little acceptance in this country.

*Chronic rheumatoid arthritis* may begin with symptoms similar to the articular manifestations of rheumatic fever. The view that this represents a chronic stage



PLATE V



TISSUE CHANGES IN RHEUMATIC FEVER.

- A, Aschoff bodies in the myocardium
- B, section of a subcutaneous nodule
- C, diffuse lesion beneath the endocardium of the auricle







of rheumatic fever finds some support in the fact that subcutaneous nodules may occur in either disease. Dawson and Boots have shown that these are identical histologically. Against this conception is the tendency of rheumatoid arthritis to spare the heart; nor is it complicated by chorea. Rheumatoid arthritis usually affects the small joints more than the large ones.

Such contentious questions cannot be answered until the etiological agent of rheumatic fever is definitely settled.

**Symptoms.**—A rheumatic attack may be ushered in by one or more of the characteristic symptoms of the disease, such as chorea, arthritis, subcutaneous nodules, erythema or acute carditis. Frequently only constitutional symptoms and perhaps a sore throat are present, the true nature of the attack being missed entirely, to be revealed later by the development of cardiac disease or by a recrudescence with some obviously rheumatic symptom.

*General Manifestations.*—An acute attack is usually accompanied by constitutional disturbance, although the symptoms are seldom as marked as with adults. The temperature usually ranges between 100° and 102° F., rarely is it as high as 103° or 104° F. Extreme hyperpyrexia with fulminating symptoms we have not seen in childhood. There is usually moderate fretfulness, malaise and some prostration; the appetite is lost; there may be a sore throat. The pulse is elevated in proportion to the temperature or more so, an excessively rapid pulse being suggestive of cardiac involvement. A moderate leukocytosis is usually present, seldom exceeding 20,000. In some cases constitutional symptoms are wanting altogether. Articular symptoms, chorea or nodules may appear with the fever or may develop after several days. The onset may be accompanied by various forms of erythema, by purpura or by epistaxis. Attention is seldom attracted to the heart until some days have elapsed.

The duration of the acute phase of the disease is variable. The constitutional symptoms may clear up within a few days or may last two or three weeks; they may recur at short intervals for many months, after which the process may subside for an indefinite time.

Chronic cases in which acute manifestations have continued, and particularly cases with cardiac involvement, are likely to exhibit a marked secondary anemia. Growth and nutrition may be seriously affected. It is not an uncommon experience for a child to be brought to a physician because he is pale and underweight, in whom an examination reveals unsuspected rheumatic heart disease. Extreme cases of this sort are sometimes referred to as "mitral dwarfism."

*Joint Symptoms.*—These are apt to be very mild in young children; only in late childhood are the acutely inflamed, red, tender joints, so characteristic of the adult disease, encountered. The number of joints involved is generally small, those most frequently affected being the knee, ankle, hip and elbow, sometimes the small joints of the wrist or foot. A number of joints may be attacked in succession as in adults, but more often the process is limited to one or two. The joints of the upper extremity appear to be less frequently involved, but this may be because disease here is more readily overlooked. Swelling is moderate and may not be evident except on close examination; in some cases there is none. Tenderness, rarely localized, may affect the ligaments, tendons and the muscles. The symptoms



are rarely severe enough to keep the patient in bed; there may be sufficient pain on motion to prevent walking, or perhaps only a slight stiffness, causing him to walk with a limp. Muscular spasm may be very striking, lasting from a few days to three weeks or more; in such instances tuberculous arthritis is often suspected. The tuberculin reaction and the response of rheumatic joints to salicylates should help one to distinguish between them. Involvement of other joints and the appearance of other rheumatic symptoms often settles the question. Rheumatic symptoms are sometimes confined to the periarticular tissues rather than the joints themselves; the nature of the process often passes unrecognized, being dismissed as simply "growing pains."

*Cardiac Manifestations.*—The frequency of carditis in acute rheumatic attacks is very great. In perhaps 50 to 60 per cent of the cases definite clinical evidence of cardiac damage can be recognized during the acute phase. The heart is probably affected to some extent even more frequently than this, for Swift has shown that if daily electrocardiograms are taken, fully 95 per cent of such patients will show at least a transient abnormality. The earliest signs are usually confined to the myocardium: tachycardia out of proportion to the degree of fever and a soft systolic murmur heard best at the apex; electrocardiograms may reveal some prolongation of the P-R interval or deformity of the ventricular complexes. Such findings are not of bad prognostic import; they often disappear entirely, leaving the heart without appreciable injury. With more extensive carditis, enlargement of the heart may be detected by roentgenogram or physical signs; there is usually a well-defined systolic murmur heard over the entire precordium and often transmitted. With severe carditis there are symptoms as well as physical signs—prostration, weakness, dyspnea, cyanosis or precordial pain, and eventually any of the evidences of decompensation. In some cases with extensive myocardial damage the heart sounds become weak and almost inaudible; the muscular quality of the first sound disappears, leaving it with a valvular quality much like that of the second sound; this is the so-called "tic-tac" rhythm. A mid-diastolic sound, apparently an exaggeration of the third heart sound, is easily heard (gallop rhythm). The conducting system is affected to some extent in many cases; sometimes this is a prominent feature; there may then be dropped beats, 2 to 1 heart block or, rarely, complete heart block. There may be frequent extrasystoles. Although the conducting system is more likely to be affected in severe cases, there are notable exceptions to this. We have several times seen partial heart block as the only evidence of rheumatic carditis that could be made out by clinical examination. A slow heart accompanying an acute rheumatic attack is not necessarily due to heart block; we have seen a few instances in which the onset of rheumatic infection was accompanied by a marked sinus bradycardia.

Although valvulitis is usually present in acute attacks and develops quite as early as myocarditis, it does not as a rule produce early signs. It is probable that the presence of vegetations may contribute to the rasping and musical quality of some of the early heart murmurs.

Pericarditis, although a frequent lesion at autopsy, is recognized clinically in only 10 to 15 per cent of acute attacks; it may give no signs whatever. Pericardial friction rubs may be very transient, lasting only a few hours, or may persist more



than a week. Pain may be a prominent feature or may be absent altogether; there is no hard and fast relation between pain and friction sounds; with marked pain there is likely to be immobilization of the chest with abdominal breathing. The classical friction rub is a to-and-fro leathery sound, originating close to the ear; it may, however, be audible only during one phase of the cardiac cycle. Friction sounds are more common at the base of the heart, particularly in the second and third left interspaces close to the sternum, but there is no constancy about this. A rub may be heard at any one point over the precordium; sometimes two or three distinct rubs can be identified; in other instances friction may be heard over the entire precordium.

Pericardial effusions when small give no physical signs; the presence of moderately large effusions may coexist with friction sounds at the base of the heart. Large effusions may be readily confounded with a greatly dilated heart—both roentgenologically and by physical signs. With an effusion the heart sounds are likely to be muffled while the pulse remains of fair quality; the diffuse, wavy cardiac impulse seen in greatly dilated hearts is not found with effusions; in them the apex impulse may disappear entirely. Rheumatic effusions rarely require paracentesis.

Only a small proportion of cases of rheumatic carditis are fatal during the first attack; in the majority recovery takes place leaving a heart partly crippled. As the attack subsides there is gradual improvement in myocardial function, evidenced both by symptoms and physical signs. Decompensation, when present, tends to clear up, the size of the heart decreases, murmurs and other signs of dilatation diminish, leaving behind the evidences of valvular damage and perhaps of pericardial adhesions. Physical signs of valvular sclerosis usually require at least four to six weeks to develop, if one may judge by the time of appearance of aortic diastolic murmurs; the early mitral murmurs are almost exclusively myocardial in origin. Improvement may continue for some time after the attack, making it difficult to estimate the amount of permanent cardiac damage. The size of the heart seldom returns quite to normal. Owing to the mechanical disadvantage under which it labors, it must hypertrophy in order to carry out its work. When valvulitis has been out of proportion to the myocardial damage, hypertrophy may replace dilatation without appreciable changes in the outline of the heart; the heart appears to “fill from within.” The abnormalities of conduction seen in the acute phase are usually short-lived, although we have known heart block to persist for months. Evidences of acute pericarditis seldom last more than a week or two at the most.

*Chronic Rheumatic Heart Disease.*—The late results of rheumatic carditis are seldom due to a single acute attack. Valvular deformities like mitral stenosis must be attributed rather to repeated recrudescences of a latent process. Few infections show such a tendency to relapse as does rheumatism. A single attack which does not recur is rare; most patients have three or four definitely rheumatic episodes, and doubtless many more flare-ups so mild as to pass unnoticed; such would seem to be the explanation of the rheumatic lesions in which no history of acute attacks can be obtained. Each of these recurrences—severe or mild—usually means renewed activity of disease in the heart. The career of many of these patients



develops into a series of battles with rheumatic activity, separated by weeks or months of quiescence; with each attack the ground gained in the intervals is generally lost. In other instances, after one or more attacks of acute carditis the process seems to subside and the patient settles down to a life of more or less severe cardiac invalidism. The likelihood of renewed bouts of activity seems to diminish with increasing age.

The evidences of chronic rheumatic heart disease do not differ essentially from those found in adults. The symptoms and signs of valvular lesions, of pericardial adhesions and of circulatory failure are identical; these are described elsewhere.

A few peculiarities of cardiac rheumatism in children may be mentioned here. Deformity of the chest is more marked when the heart is involved in early life. Growth and nutrition are more likely to suffer; puberty is often delayed. Mild degrees of clubbing of the fingers may be seen in children with extensive rheumatic disease, but almost never in adults. Decompensation in children is usually due to a fresh carditis rather than to a played-out myocardium without active infection. This perhaps explains why the child is less likely to develop generalized anasarca and extreme evidences of chronic passive congestion of the viscera, while dyspnea and pain are usually more prominent. Auricular failure, as evidenced by fibrillation, is less frequent in children; flutter is almost unknown.

*Chorea*.—This is discussed in detail elsewhere. The rheumatic nature of chorea is no longer questioned. It may occur as the only rheumatic manifestation; it may be accompanied or followed by any part of the rheumatic picture. Cases beginning with chorea seem to have a better prognosis than those beginning with arthritis, nodules or with cardiac symptoms. A little more than half of the chorea cases develop cardiac lesions, while with articular symptoms and subcutaneous nodules the incidence of carditis is probably greater than 90 per cent. In Coombs' series, the mortality in cases followed for ten years was as follows:

<i>Beginning with</i>	<i>Per Cent Dying within 10 Years</i>
Nodules .....	50
Cardiac symptoms without nodules.....	25
Joint symptoms .....	20
Chorea .....	3

Coombs regards chorea as a benign form of infection, the nervous system being highly sensitive and responding to small doses of the infectious agent. This view is not supported by individual cases. A mild attack of chorea may be accompanied by severe carditis and *vice versa*.

*Subcutaneous Fibroid Nodules*.—General attention was first drawn to these as a manifestation of rheumatic infection by Barlow and Warner in 1881, who described them as oval, semitransparent fibrous bodies like boiled sago grains. They may be found over the malleoli, at the margin of the patella, on the elbows, the extensor tendons of the hands, fingers or toes, in the scalp or over the spinous processes of the vertebrae or the scapula. They vary in size from a large pin's head to a small bean, but occasionally may be almost as large as a peach pit. They



are better felt than seen, but may be visible if the skin is tightly drawn. The nodules often come in crops which may last for a few weeks and then disappear, or may remain for months. An eruption of nodules always indicates an active process; it is usually accompanied by other evidences of rheumatic activity.

Only a small proportion of rheumatic cases in this country exhibit nodules; they are more frequent in England, where severe forms of rheumatism are apparently more common.

*Involvement of Other Serous Membranes.*—Involvement of the pleura, peritoneum and meninges was more frequently ascribed to rheumatism in the past than now. The pleura is occasionally involved by direct extension from the pericardium. Rheumatic involvement of the lungs is distinctly rare in childhood; signs of consolidation and râles, when not due to a secondary pneumonia, are usually to be explained by chronic passive congestion at the bases or by pulmonary infarction.

The development of abdominal pain in association with rheumatic attack is an uncommon occurrence which may cause confusion in diagnosis; occasionally this leads to an unnecessary laparotomy. In some instances direct extension of the rheumatic inflammation from the pericardium to the diaphragmatic peritoneum has accounted for the pain; in others no such lesion could be found. It seems likely that a low-grade localized peritonitis may account for this pain, but the lesion is not necessarily diaphragmatic, nor does involvement of the diaphragm invariably produce pain.

There is no evidence that the meninges are directly affected by rheumatism.

**Signs Which May Be Rheumatic.**—*Erythema.*—The connection between rheumatic fever and the various types of erythema multiforme was first indicated by Cheadle. Such an eruption should always suggest the possibility of an active rheumatic process. Some instances of erythema nodosum are apparently rheumatic.

The association of *purpura* with rheumatic fever is at times so close that there can be little doubt of the connection between the two. However, not all cases of purpura with arthritis can be attributed to rheumatism. Rheumatic purpura is dependent on increased capillary permeability rather than on a deficiency of blood platelets.

The association of *tonsillitis* and *pharyngitis* with rheumatic fever appears in many cases to be a close one. Children who are the subjects of frequent attacks should be regarded as possibly rheumatic and closely watched for other evidences of that disease. It is by no means clear that the tonsillitis itself is a rheumatic inflammation; it may be that an inflamed tonsil provides a suitable portal of entry for the rheumatic agent. The bacteriology of the throat at the time of the rheumatic flare-up shows no constant changes. Coburn, however, has emphasized the frequency with which a beta-hemolytic streptococcus can be cultivated from the throats of rheumatic subjects from one to three weeks prior to the onset of a period of rheumatic activity.

*Anemia.*—A secondary anemia commonly accompanies acute attacks and persists between them. When the attacks have been frequent and severe, this may reach considerable severity and add to the embarrassment of the circulation.



*Myalgia.*—A variety of muscular pains were formerly grouped under the term muscular rheumatism, which was considered a definite manifestation of the disease. Probably only a small minority of these bear any relation to rheumatic fever. Kaiser, in a study of 105 children who complained of “growing pains,” was able to discover other indubitable evidences of rheumatism in only 18 per cent. The most clean-cut myalgia to which children are subject—the stiff, sore neck which comes on acutely, producing torticollis, and clears up in a few days—is usually nonrheumatic in origin. In rare instances torticollis is due to rheumatic involvement of the cervical spine.

**Course and Prognosis.**—The tendency of rheumatic infection to recur has already been emphasized. Periods of activity may follow each other at short or long intervals. There may be a recurrence of the same rheumatic manifestation, but quite as often a child who is first seen with nodules or erythema will with his next attack develop chorea or articular symptoms and may eventually run the entire gamut of rheumatic symptoms. The danger of the disease lies in cardiac involvement. Even if the heart should be fortunate enough to escape in the first attack, it seldom does so a second or a third time. Once the heart has been affected its lesions are likely to spread with each recurrence. The pediatrician who may not have the opportunity of following his cases into adolescence or adult life is likely to underestimate the ultimate ravages of the disease.<sup>1</sup> The mortality statistics collected by Coombs are illuminating. Of children showing unmistakable evidence of cardiac disease before the tenth year:

5 per cent died within	a year
11 per cent died within	5 years
21 per cent died within	10 years

His data also showed that the ultimate prognosis in cases of “doubtful or suspicious cardiac disease” was little better than in the group with unmistakable lesions. At least one-third of the doubtful cases developed definite signs of valvular disease within ten years. The following table is taken from Coombs:

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<sup>1</sup> The course and termination of these cases are well illustrated by the following history of a girl who was under observation for nine years: When first seen she was seven years old, and had had cardiac symptoms for one year. There was then present a loud mitral regurgitant murmur, with considerable hypertrophy. There was general anasarca. Under treatment, the dropsy and other symptoms disappeared, and she went on comfortably for over a year. In her eighth and ninth years there were frequent attacks of subacute articular rheumatism and the heart lesion steadily increased in severity. At twelve years there was an eruption of subcutaneous fibroid nodules, which remained for over two years. During this year there was heard for the first time a presystolic mitral murmur, accompanied by a very marked thrill, mitral stenosis having been gradually brought about by the slowly progressing endocarditis. This murmur gradually increased in intensity from that time, while the mitral regurgitant murmur became less distinct. The apex beat was then in the sixth space, two and a half inches to the left of the nipple. From the twelfth to the fifteenth year she grew very little in height or weight, and showed no signs of maturity. The cardiac symptoms were nearly stationary. In the fifteenth year she developed a marked enlargement of the liver and spleen with general dropsy and all the symptoms of cardiac insufficiency, these being the first symptoms of this character since she was seven years old. There was now heard for the first time an aortic regurgitant murmur in addition to the others formerly present. The symptoms disappeared under treatment in the course of a few months, but six months later returned with greater severity and were accompanied by albuminuria, the patient dying from heart failure in a few weeks. During the last exacerbation there was heard a double aortic as well as a double mitral murmur.

At autopsy the heart weighed 450 grams. There was a very great hypertrophy, especially of the right ventricle, which was as thick as the left. All the cavities were much dilated. The most important valvular lesion was mitral stenosis, the orifice not admitting the end of the little finger. The valves were the seat of calcareous deposits. The cusps of the aortic valve were thickened and adherent; there was also thickening of the pulmonic and tricuspid valves.



TABLE LVIII

Outcome	Early Signs of Heart Disease Suspicious or Doubtful, Per Cent	Early Signs of Heart Disease Definite, Per Cent
Recovery .....	44	31
Death before 20 years of age.....	19	28
Death before 30 years of age.....	28	38
Death before 40 years of age.....	39	50
Survival after 40 years with crippled heart.....	17	19

When recovery occurred the signs usually disappeared within two years. Among the well-to-do, where ideal conditions can be maintained, the prognosis is probably somewhat better than these figures would indicate.

To predict the outcome in a given case is not possible. The likelihood of renewed activity with further cardiac damage cannot be estimated. As a rule, the younger the child, the greater the probability of recurrences and the worse the prognosis. Fully two-thirds of our patients showing definite cardiac lesions before the age of six have failed to reach puberty. In individual prognosis, symptoms are more valuable than signs. The dictum of Coombs that “physical signs are good servants but bad masters” is worthy of repetition. We once saw a young adult with classical signs of mitral stenosis and insufficiency who was a professional swimmer and excelled in underwater swimming, showing less than the normal degree of dyspnea on exertion. The astonishing recoveries which children sometimes make afford evidence that the condition of the myocardium rather than that of the valves determines the efficiency of the heart. The prognosis is certainly less favorable in cases with evidence of aortic or tricuspid disease or cases with clinical evidence of pericarditis; this is not so much because of the disability produced by these lesions as because they are indications of a severe and widespread infection.

Any evidence of renewed rheumatic activity must be regarded as ominous. Fibrillation puts an added strain upon the ventricle and carries an unfavorable import; the average duration of life with this symptom in Coombs’ series was two years. Any evidence of progressive circulatory failure is, of course, unfavorable; a falling blood pressure, weak heart sounds, sudden disappearance of murmurs and pulsus alternans are ominous signs.

Many cases succumb to complications—any acute infection such as pneumonia or pertussis is more likely to be fatal in the presence of a rheumatic heart lesion. According to Coombs one patient in every 16 dies from viridans endocarditis.

**Diagnosis.**—Rheumatic infection in childhood is more often overlooked than confounded with other diseases. In order to recognize it one must free one’s mind from the picture of the disease as it exists in adults. In early life the disease is recognized by the association of a number of conditions apparently unrelated. A positive family history is of some importance; a history of repeated sore throats, indefinite growing pains or other possibly rheumatic manifestations is even more



so, and most important of all is a history of definite rheumatic episodes. The patient must be examined from the rheumatic point of view. A diligent search for nodules in all possible locations will sometimes enable one to make the diagnosis of an obscure febrile attack. In all fevers of unknown origin the heart should be carefully examined, not only during the acute attack but for several weeks thereafter. Chorea rarely presents diagnostic difficulties to one who has seen it; the obscure cases are those in which weakness is out of proportion to the involuntary movements. In evaluating joint symptoms the age of the patient is of great help. The extreme infrequency of rheumatic infection in the first two years should make one skeptical about it. Swellings about the joints in infancy are usually due to scurvy, sometimes to pyogenic infection. Even after the fourth year, when rheumatism becomes frequent, joint symptoms are seldom pronounced. Tuberculosis and rheumatoid arthritis as a rule come on more insidiously; the latter, unlike rheumatic fever, has a special predisposition for the small joints. Syphilitic bone disease occasionally causes confusion. Considerable difficulty may arise in cases of gonococcus arthritis involving several joints subacutely. When there is a large effusion into a single joint one should always suspect pyarthrosis rather than rheumatic fever.

With an acute rheumatic process of any kind the question invariably arises: *Is the heart involved?* Functional tests which require exercise should be postponed until after the acute phase is passed. Precordial pain, enlargement of the heart, diastolic and presystolic murmurs are evidences of organic heart disease which are beyond dispute. The greatest difficulty lies in interpreting a systolic murmur in the absence of cardiac enlargement. In deciding whether such a murmur is functional or organic one must consider its location, its constancy and the extent of anemia which may be present. A murmur is more likely to be functional if it is loudest at the base and if it changes markedly or disappears with change in the body position. With the exception of sinus arrhythmia the development of any disturbance in rhythm—extrasystoles, dropped beats or heart block—is significant. A prolonged conduction time or abnormal ventricular complexes visible in the electrocardiogram are evidences of cardiac involvement; also an unusual degree of tachycardia. Changes in the quality of the heart sounds, or the onset of gallop rhythm are indications of myocardial disease.

The determination of the *extent of involvement* and the significance of individual symptoms are matters of experience. In the acute phase one must judge by the evidences of decompensation, by the quality of the pulse and heart sounds, the presence of gallop rhythm, etc. Anomalies of conduction are not very helpful; they may exist as the only evidences of a heart lesion or they may be associated with extensive heart disease. With convalescence the cardiac lesion is best measured by functional tests taken up in the section on treatment. The difficulties in individual prognosis have already been discussed.

The question sometimes arises whether a bacterial endocarditis is present in addition to the rheumatic process, particularly when fever and anemia are present; a purpuric eruption may add to the difficulty. The fever of acute rheumatic attacks seldom lasts for more than two or three weeks at a stretch, while that of viridans endocarditis fluctuates more widely during a twenty-four hour period and rarely



remains normal for more than a day. Evidences of acute nephritis or enlargement of the spleen out of proportion to the signs of chronic passive congestion should suggest a viridans infection; clubbing of the fingers is often marked; sooner or later a positive blood culture and definite embolic phenomena are sure to make their appearance.

**Treatment.**—During the acute attack one's objective is to afford symptomatic relief and to limit as far as possible the cardiac damage. The treatment of chorea—largely a matter of sedatives—is discussed elsewhere. The joints require no local applications as may be the case with adults; they clear up readily under salicylates. Treatment of acute rheumatic attacks is a matter of rest, salicylates or similar drugs, and perhaps sedatives. It is reasonable to suppose that the less the strain put on the heart, the less damage that organ is likely to suffer. The patient should be kept on his back for at least two weeks after the acute attack has subsided. This regimen should be enforced regardless of whether or not there are evidences of cardiac involvement; the disease must be regarded as active in the heart if it is active elsewhere. To determine the presence of activity may be difficult when the patient is under the influence of antipyretics, which may abolish fever and joint symptoms entirely. If there is reason to suspect cessation of activity these drugs should be withdrawn. An acute flare-up may be afebrile, however, even if no drugs have been given. Signs of an active process are fever, leukocytosis, increasing pallor, failing nutrition, a rheumatic skin eruption, an eruption of nodules, the persistence of articular symptoms, the appearance or exacerbation of chorea, or in fact any rheumatic manifestation. An exacerbation of cardiac symptoms or signs indicates activity: undue tachycardia, development of gallop rhythm or of impaired conduction, enfeeblement of the pulse or heart sounds, an increase in dyspnea, pain or other evidences of circulatory failure, the persistence of pericardial friction. Conversely, a fading skin rash, disappearance of nodules, disappearance of pericardial rubs, improvement in cardiac function, in nutrition and in disposition, and a temperature which remains flat after the withdrawal of antipyretics—all indicate a cessation of activity. As cardiac function returns it may happen that murmurs which have been feeble become louder.

Rigid observation must be continued even after one is satisfied that the acute process has subsided. Activity may return at any time, the first attack being the precursor of a series of active periods covering months. If two or three weeks have elapsed without evidence of a new flare-up, the restrictions on the patient's activity should be gradually relaxed. The effect of exertion upon the patient's pulse rate will determine how rapidly this may be done. No exertion should be permitted which causes an increase in the patient's pulse rate lasting more than three or four minutes.

With an extremely active child it may be difficult to enforce prolonged rest in bed. Occupation of the child's mind is quite essential if the program is to be carried out. It is usually unwise to resort to sedatives merely to restrict activity; they may be indicated for the relief of precordial pain in acute carditis; an ice-bag may also do much to relieve such pain.

Although salicylates are often spoken of as specific antirheumatic drugs, it is highly doubtful that they possess any such effect. They will abolish fever, joint



swellings, muscle pains and tenderness, and hence give marked symptomatic relief, but there is no evidence that they shorten the course of the infection or limit its spread. However, in the hope that they may possess some specific action, they are usually given routinely in all acute rheumatic flare-ups. Sodium salicylate may be given in divided doses up to a total of 60 grains (4 grams) a day to a five-year-old child; double this quantity may be given to a child of ten. The drug should be combined with an equal amount of bicarbonate of soda to prevent nausea. It should be continued throughout the acute attack. The dose will vary to some extent with individuals; sometimes a smaller dose will effectively reduce temperature and joint pain, sometimes more is required. Aspirin is quite as satisfactory as sodium salicylate and is less nauseating; the dosage is identical. A number of cincophen derivatives have been used lately to replace salicylates; we have used tolysin to some extent and found it satisfactory. It is not nauseating and does not require the simultaneous administration of bicarbonate; the dose required is approximately twice that given for salicylate. Other antipyretics such as pyramidon have been used with success.

Salicylate poisoning is occasionally met with; the symptoms are dizziness, ringing in the ears, vomiting and sometimes renal irritation; an acidosis due to salicylic acid has been described. One should always be on the watch for such untoward symptoms. Poisoning from cincophen derivatives has also been described<sup>2</sup>; these may produce acute yellow atrophy of the liver. Both salicylates and cincophen derivatives may cause signs of renal irritation—hematuria and casts. A number of specific streptococcus sera have been used in acute rheumatic attacks, with results which are not convincing.

Following an acute attack, much can be done to prevent recurrences. Attention should be given to the diet and to the treatment of anemia if this is present. Exposure to dampness and cold should be avoided. If possible, such patients should spend the winter and spring in some warm, dry climate or even remain there permanently. The results obtained by Coburn, who removed a group of rheumatic children from New York City to Porto Rico for the winter months, were most encouraging; after the first few weeks not a single recurrence was noted during this period.

It seems reasonably certain that upper respiratory infections—not only tonsillitis, but common colds, sinusitis, etc.—all predispose to rheumatic recurrences. Such infections should be avoided when possible. Known foci of infection should be removed. The results of tonsillectomy have on the whole been disappointing. Kaiser, in a most extensive study, was unable to show that recurrences were reduced, although he did find that first attacks of rheumatism developed less frequently in children whose tonsils had previously been removed. The routine removal of tonsils in rheumatic children should be deprecated; they should be taken out only when obviously diseased. We have seen several instances in which bacterial endocarditis has directly followed the removal of tonsils or teeth in rheumatic patients.

The rheumatic child should always be kept under close observation in order

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<sup>2</sup> *J. Am. M. Ass.*, 1928, 91: 310; 1930, 95: 1228.



that a recurrence may be recognized at the start. When there is any indication of renewed activity he should be put to bed.

*Treatment of the Rheumatic Heart.*—The amount of exercise that a child with a heart lesion may be permitted must be determined empirically. There is no advantage in continuing complete rest longer than two or three weeks after the acute process has subsided; to do so is only to encourage invalidism and perhaps to impede the return of cardiac function. If there is decompensation, rest in bed must of course be continued until this clears up. Even in markedly edematous patients little can be accomplished by the rigid restriction of fluids, such as has been commonly employed in the past; certainly this should not be carried to the point of discomfort. The technic of paracentesis of the serous cavities is discussed elsewhere. Small effusions do not require tapping; this should be employed only with large effusions which may in themselves cause additional cardiac embarrassment. Diuretics such as theobromine sodium salicylate (diuretin) may be of some help in cases of massive edema. Salyrgan is a more powerful diuretic but should not be employed except as a last resort because of its possible irritating action on the kidney. The relief of edema by purging is not to be recommended. In extreme cases Southey's tubes may be employed.

Recovery from decompensation is best estimated by following the size of the liver, the vital capacity, the pulse and respiratory rate, and, in patients with edema, the weight. When compensation has been regained the capacity of the heart can be followed by observing the response to exercise—the amount that can be taken without producing dyspnea, or the response of the pulse to a specified amount of exercise. It is unwise to allow activities which produce a prolonged tachycardia; if the patient's pulse rate does not return to its previous level within four minutes after the exercise has stopped, it may be regarded as excessive.

Older children can often be allowed to regulate their exercise themselves, since dyspnea will usually check overexertion automatically. There are many exceptions to this, however. Children who are ambitious and excitable may require restraint, while others slip easily into a career of invalidism and need to be stimulated; if too little exercise is taken the heart, like the voluntary muscles, suffers from disuse. A proper selection of games and other interesting activities should encourage the patient without subjecting him to the strain of competitive sports or to the drudgery of measured walks and regulated calisthenics.

The convalescent home—a comparatively recent development in this country—is proving invaluable in the treatment of these cases, providing as it does opportunity for medical supervision, for graduated exercise within the patient's tolerance and, in some instances, for vocational training in sedentary occupations.

Mechanical measures for the relief of chronic cardiac deformities are still in the experimental stage and seem likely to play little part, in children at least. Successful valve surgery has been reported by Cutler in cases of advanced mitral stenosis. Operations for the relief of extrapericardial adhesions, though less dramatic, may in some instances be very helpful. Unfortunately the children with marked pericardial adhesions usually have advanced valvular and myocardial disease and are poor operative risks. The indications for operation are: extensive pericardial adhesions with a minimum of endocardial and myocardial involvement.



The importance of treatment of the secondary anemia in chronic heart disease cannot be too strongly emphasized. Improvement in the blood picture almost invariably brings about improvement in cardiac function.

*Auricular fibrillation* is seen infrequently in children; its onset is usually accompanied by some loss of cardiac reserve. When seen soon after its onset one may properly make the attempt to restore the normal rhythm by means of quinidine. If fibrillation has persisted for months this involves a certain amount of risk; restoration of the normal rhythm sometimes dislodges an old thrombus from the auricular wall, causing fatal embolism. Quinidine should be given as the sulphate in 5-grain doses four times a day. If the effect is not obtained within a week nothing further is to be expected and the drug should be tapered off and stopped within a few days. Digitalis may assist the action of quinidine in restoring rhythm. Digitalization of the heart is of the greatest value in cases of fibrillation in which normal rhythm cannot be restored. It acts as a cardiac sedative, preventing many of the abnormal auricular stimuli from penetrating to the ventricle which is then allowed to beat in a slower, more forceful way. Digitalization seems also to be of some benefit in cases of decompensation with edema, for reasons which are not clear. Its action in such cases is neither constant nor striking, nevertheless at times it seems to induce slowing of the pulse with symptomatic improvement. Only an active standardized preparation should be used, the full digitalizing dose being calculated by body weight: for older children this amounts to 0.2 c.c. (3 minims) of a good tincture or 20 milligrams ( $\frac{1}{3}$  grain) of the powdered leaf per pound; young children require somewhat more. Half the digitalizing dose may be given at once, the remainder in two equal doses at four- or six-hour intervals following this. The amount required to sustain digitalization is from 0.5 to 2.0 c.c. (7 to 30 minims) of the tincture per day or from 0.05 to 0.2 gram ( $\frac{1}{2}$  to 3 grains) of the leaf. The effects of digitalis can be detected by the electrocardiogram within four or five hours; within twenty-four hours they are usually noticeable clinically. Vomiting, extrasystoles or a bigeminal pulse are indications of overdosage, sometimes heart block. The drug should be withheld until these symptoms disappear. If there is evidence of second or third degree heart block in the first place, digitalis should be avoided. Simple prolongation of conduction time should not be regarded as a contraindication to its use.

*Sedatives* are often required for the relief of precordial pain in acute carditis or in chronic cases with failing compensation. Opiates in full doses may be necessary. Some relief may be obtained by a precordial ice-bag, but this is seldom effective.

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## CHAPTER CXXXIX

### CHOREA

Rheumatic chorea (chorea minor, Sydenham's chorea, St. 'Vitus' dance) is a functional disorder of the nervous system characterized by sudden aimless, irregular movements, often accompanied by muscular weakness and a mental condition of extreme irritability.

Choreiform movements are seen in certain organic diseases of the nervous system, notably in epidemic encephalitis. Posthemiplegic chorea following cerebral accidents occurs in adults but rarely in children; it has, however, been described as a result of birth injury. Hereditary chorea (Huntington's chorea) does not begin until later life.

Nearly all cases of chorea observed in children belong in the rheumatic group, and it is this entity to which the present discussion will be limited.

**Etiology.**—Sydenham's chorea is most frequently seen between the ages of seven and fourteen years. The youngest case we have seen was in a child of three; before this it is extremely rare. It occurs twice as often in females as in males and is distinctly more common during the spring months. After puberty it is rarely seen.

It is now clearly recognized that chorea is a manifestation of rheumatic infection; it is closely associated with other rheumatic phenomena, and the development of an attack of chorea may be regarded as evidence of active rheumatic infection.

Cases of rheumatic fever in which chorea is a prominent symptom are less frequently associated with active endocarditis than are those in which joint symptoms and especially skin lesions and nodules are present; the reason for this is not clear.

A predisposition to chorea seems to exist in certain families. It is not rare to see several members who have been affected, and sometimes there is a history of chorea in the parents. Chorea seems to attack high-strung neurotic children with greater frequency. Overpressure at school is often blamed. In some instances choreic symptoms are manifested with great suddenness after a fright.

**Pathology.**—There has been little constancy in the findings in patients who have died with chorea. Periarterial lesions, bearing some resemblance to those of rheumatic fever elsewhere, have been described in the brain in some instances. In other cases no such lesions have been found although carefully searched for, and one must assume that the disturbance is functional. There is still some doubt as to whether the seat of the morbid process is in the cortex or the basal ganglia.

**Symptoms.**—An attack of chorea generally comes on gradually. At first the child may be considered simply as unusually nervous; if at school, there may be noticed difficulty in writing, drawing, or in using the hands for other delicate



operations. At home, the child is continually dropping things, has difficulty in feeding himself, sometimes in buttoning his clothes; and very frequently he is not brought to the physician until the symptoms have lasted a week or two. Sometimes the legs are first affected, and a history is given of frequent falls, a stumbling gait, difficulty in going upstairs, etc. At other times the abnormal muscular movements are first seen in the face, with disturbance of articulation and twitchings of the eye muscles, and the child may be punished for making grimaces. In most cases the spasmodic movements soon extend to all parts of the body. They remain limited to one side of the body (hemichorea) in about one-tenth of the cases. When fully developed, the movements of chorea are quite unmistakable. They are irregular, jerking, spasmodic, never rhythmical, rarely symmetrical, and vary in intensity from an occasional muscular contraction to almost constant motion. The movements are not under the control of the patient's will, and are usually intensified by efforts to repress them. They are increased by excitement, embarrassment, or fatigue, but do not continue during sleep.

Very often there is weakness of the affected muscles, which may be so great as to lead to the suspicion that actual paralysis exists. Not infrequently we have had patients brought to the clinic for supposed paralysis, either of one extremity or of one side of the body, where the choreic movements have not been severe enough to attract the attention of the mother. This paresis usually disappears in the course of a few weeks. Normal muscular movements are poorly sustained. An attempt to grip the hand hard produces a spasmodic contraction which is rapidly relaxed.

In severe forms of chorea the patient may be unable to walk, to speak intelligibly or even to sit up in bed or eat. The movements may be so violent that it is necessary to pad the bed and to wrap the child's extremities in cotton. Control of the bladder or rectum may also be lost. The symptoms may be so intense as even to threaten life. Such cases are dangerous, not from the choreic movements, but from the acute carditis with which they are frequently associated. We have seen fatal cases, however, in which the outcome was not determined by the cardiac lesion. The temperature usually rises to 103° F. or more and remains constantly high. The choreiform movements are almost impossible to control even with sedatives in enormous doses, and death takes place after several days, apparently as the result of exhaustion.

The mental condition of choreic patients is one of marked irritability. They are fretful, emotional, easily provoked to tears or laughter, and difficult to control. In extreme cases a mental disturbance bordering upon acute mania has been observed. In other cases the facial expression and manner of speech strongly suggest beginning imbecility. All degrees of speech disturbance are seen, from the slight difficulty in articulation, due to inability properly to control the movements of the tongue and lips, to a condition in which speech is impossible.

Cardiac murmurs are frequent in chorea. Some of these are functional in origin, but a large number are due to organic heart disease. During and after every attack the heart should be closely watched. There can be little doubt that many of the murmurs which subsequently disappear and are often regarded as functional are in reality due to slight myocardial lesions.



The general condition of choreic patients is usually much below normal. Their appetite is poor, often capricious, and during the attack they lose greatly in weight. They are anemic and tend to become progressively more so as long as the disease is active. They sleep badly; they suffer frequently from headaches; they are easily fatigued by slight muscular exertion. In cases uncomplicated by carditis, fever is generally absent or, if present, of distinctly mild degree. An eosinophilia is an inconstant but at times a striking phenomenon; as many as 20 per cent of the leukocytes may be eosinophils. The erythrocyte sedimentation rate is markedly accelerated at the height of the attack, even in cases not accompanied by fever.

**Course and Duration.**—The ordinary form of chorea tends to spontaneous recovery in from six to ten weeks. Exceptionally it may last for three or four months. In a small number of cases the disease may continue for a much longer period with remissions and exacerbations. The tendency to relapses and second attacks is very marked. Later attacks are likely to occur in the spring succeeding the first illness, and in a small number of patients attacks may come every year for four or five years.

**Diagnosis.**—As a rule there is little difficulty in recognizing choreiform movements if one has ever seen a case. Athetoid movements are slow, irregular and have a spastic character. In habit spasm the movements give evidence of a purposeful character and are repeated. A condition closely simulating chorea may arise from imitation and has been known to occur epidemically in institutions. Epidemic encephalitis with choreiform manifestations may give rise to difficulty. This may occur in subjects under three years. Other evidences of encephalitis and lumbar puncture should enable one to distinguish it.

Occasionally the muscular weakness in chorea is such a prominent feature that one is likely to suspect a vascular lesion. This is particularly true in cases of hemichorea.

**Prognosis.**—As a rule this is favorable, and complete recovery from the chorea can usually be predicted, the exceptions being few in number. Parents should always be warned of the tendency of the disease to return in succeeding years, and the fact should be stated that in a certain proportion of cases the disease may be of exceptional duration. The prognosis of the cardiac murmurs occurring in chorea should always be guarded, although some of these are functional and disappear with recovery from the chorea; but the number of those which do not disappear is very large and sufficient to make one always apprehensive as to the ultimate result.

**Treatment.**—A child with chorea should at once be taken from school, and should never be subjected to punishment or ridicule on account of the movements.

Rest is the most important part of therapy. Complete mental and physical rest should be secured by putting the patient to bed and isolating him as far as possible. For the severe cases this cannot be too strongly insisted on, and even in mild cases it is beneficial. A certain amount of moral restraint is indispensable. Choreic patients often do badly at home where they are indulged and receive sympathy; in a hospital where they are under restraint and made to control themselves they often improve immediately. One cannot be dogmatic about the length of time the patient is to be kept in bed. Much depends on the



other rheumatic manifestations. As far as the chorea itself is concerned it is probably wise to keep all patients—even mild ones—in bed for three weeks; activity may then be recommenced under close observation. For severe cases more prolonged rest is advisable. As the chorea improves the patient may be allowed greater latitude. It is not practicable and probably not desirable to keep patients in bed until all evidences of chorea have disappeared, but their activities should be limited, and they should certainly not be allowed to return to school before the disease has cleared up.

Special attention should be given to the general nutrition. The diet should be generous and stimulants like tea and coffee avoided. Iron is indicated if there is anemia. Exercise when it is permitted should be under close observation. Massage and the use of prolonged warm baths may be beneficial.

Numerous specific methods of treatment have been advocated, none of them highly successful. Arsenic was long, and still is, regarded by some as a specific; in our hands it has not been effective. Antirheumatic drugs have no appreciable influence on chorea; they may be indicated for the control of arthritis or other rheumatic symptoms. Smith and Sutton have reported striking results in the treatment of chorea with typhoid vaccine. Any measure which produces a sharp elevation of body temperature—hot packs, diathermy, or exposure to a dense field of short-wave radio waves—may have a favorable effect. Nirvanol (phenylethylhydantoin) has been widely employed in Europe for this purpose; we have seen it cause alarming general symptoms, and have discontinued its use.

Severe chorea requires sedatives. Not only do they relieve the symptoms but in many instances apparently have a distinct influence in shortening the duration of an attack. They must be given in quantities sufficient to produce an effect, and the amount required is often enormous. Various sedatives have been employed—bromides, veronal, luminal, amytal, chloretone and others. We have found chloretone especially helpful; for a child of ten it may be given in doses of 0.3 gram three times a day until the patient is distinctly drowsy, then continued at 0.3 gram once a day for a total of about ten days. It occasionally causes a macular or maculopapular eruption on the trunk and extremities. Opiates are often necessary; morphine is at times the most satisfactory drug.

We have seen one or two extreme cases (manic choreas) which could be satisfactorily controlled only by continuous warm tub baths, such as are used for manic psychoses.

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## CHAPTER CXL

### ERYSIPELAS

This is an acute febrile disease characterized by a spreading inflammation in the deeper layers of the skin. It is usually self-limited, but may be fatal, particularly during the first two years of life. Erysipelas is not an uncommon disease, and may occur at any age. Of 137 cases observed at the Harriet Lane Home during a period of fourteen years, three-quarters were under two years of age.

**Etiology.**—The disease is produced by a hemolytic streptococcus, as was first demonstrated by Fehleisen in 1882. Although the claim has been made that the streptococci found in erysipelas comprise a fixed subgroup, the *Streptococcus erysipelatis*, it is now known that many streptococci differing widely from one another may cause the erysipelatous reaction.

The organisms usually gain entrance through a wound; in the newly born the umbilical stump is often the portal of entry. We have seen the disease develop from an empyema wound in cases of streptococcus empyema. In other instances erysipelas may develop in skin lesions produced by other organisms—furunculosis, impetigo contagiosa, varicella or vaccinia. Sometimes no preceding lesion is demonstrable. Rarely the infection appears to be hematogenous; in streptococcus septicemias it may develop as a terminal phenomenon.

**Symptoms.**—The first symptom to be noted is usually the skin lesion itself, although its appearance may have been preceded for as long as twenty-four hours by fever, malaise and anorexia. Occasionally a convulsion ushers in the disease.

The inflammation may arise on any part of the skin surface. The most common sites involved are: in the newly born, the periumbilical region; in slightly older infants, the cheek anterior to an ear discharging pus, or the diaper region subsequent to a pyogenic dermatitis; in older children the legs, because of their liability to trauma. The “butterfly type” is rather often seen, so called because of the symmetrical areas of inflammation of either cheek connected by a thin red streak over the bridge of the nose.

The lesion when first seen is often an irregularly round or oval patch, dark red in color, slightly raised, firm, hot and tender to the touch. Its edge is characteristically sharp and somewhat elevated, being accurately demarcated from the normal surrounding skin. Under certain conditions, however, the edge may not be sharp, but may present a mottled or frayed appearance. Once established, the erysipelatous lesion progresses with greater or less rapidity, the edges advancing from 2 to 10 centimeters in twenty-four hours. The advance may persist for only two or three days, or may go on until the entire skin surface has been involved. The disease may advance on one front while fading and retro-



gressing on another. The temperature remains persistently elevated as long as the inflammation spreads, often maintaining a level of 104° or 105° F. for many days. Rarely the fever is intermittent, and in very mild cases or in feeble infants there may be none. There is usually a leukocytosis of 15,000 to 30,000. Leukopenia is rare. As progress becomes retarded or stops, the temperature drops either rapidly or by lysis, and the patient's general condition shows sudden improvement. In clearing, the color of the inflamed area rapidly fades and the tension decreases, leaving the tissues boggy to the touch. This edematous condition may last for many days after the disappearance of the acute lesion, and when widespread may lead to erroneous diagnoses. Desquamation of the affected skin surface in large scaly flakes generally takes place for a few days following defervescence.

**Complications.**—When the inflammation persists in one area for a prolonged period, especially over points of pressure such as the back of the scalp, sloughing may occur, leaving deep ulcers. More frequently the infection localizes at one point and swelling and fluctuation develop. Free pus may be aspirated from these areas, from which hemolytic streptococci can be cultivated. Some children show a special tendency to such localization, developing numerous subcutaneous abscesses throughout the course of the disease. In young infants septicemia is apt to develop; indeed, the younger the patient the greater the liability to this complication. Death usually takes place soon after the blood stream is invaded, but occasionally there remains sufficient time for the appearance of metastatic lesions. Peritonitis is often the terminal complication. It is likely that this is almost invariably metastatic in nature, although on occasion it is difficult to be certain that infection has not penetrated the abdominal wall directly. It is accompanied by extreme distention, vomiting, prostration and at times diarrhea—the usual symptoms of pyogenic peritonitis.

Recurrences occur in perhaps 5 per cent of the cases of erysipelas during convalescence from the original attack. These recurrent episodes are usually very mild and clear up spontaneously within three or four days. Sometimes the infection will progress down an extremity, leaving a wake of desquamating, edematous tissue, and will then sweep back again.

While the disease is spreading, hemolytic streptococci may be cultivated without difficulty from a drop of fluid withdrawn by puncture of the edge of the lesion.

**Diagnosis.**—Generally the diagnosis of erysipelas offers no difficulty. The essential features are the marked constitutional symptoms, the hot inflammatory character of the local lesion and its sharply defined advancing edge.

**Prognosis.**—The mortality in the cases seen in the Harriet Lane Home is tabulated on page 1142. The figures illustrate the serious character of the disease in young subjects. In all but two or three of these, death occurred not as an immediate result of the erysipelas, but from one of its complications, usually a streptococcus peritonitis.

**Treatment.**—Many local measures have been used in an attempt to check the spread of erysipelas, none with striking results. The most effective appears to be intradermal injection of immune serum in advance of the lesion. When the process is localized in an extremity this will usually arrest it.

Antistreptococcus serum may be given by vein or intramuscularly. Although



TABLE LIX  
MORTALITY IN ERYSIPELAS

Age	Number of Cases	Deaths	Deaths, Per Cent
0- 1 month .....	20	16	80.0
1- 6 months .....	32	12	37.5
6-12 months .....	31	11	35.5
1- 2 years .....	26	3	11.5
2- 5 years .....	17	1	5.9
5-15 years .....	11	0	0
TOTAL .....	137	43	31.4

one occasionally sees rather striking improvement, particularly in the constitutional symptoms, following its administration, it has been our experience that the results are usually disappointing.

Transfusions of normal adult's blood are distinctly helpful. Their use has apparently lowered the mortality in cases treated at the Harriet Lane Home, as is indicated in the accompanying chart.

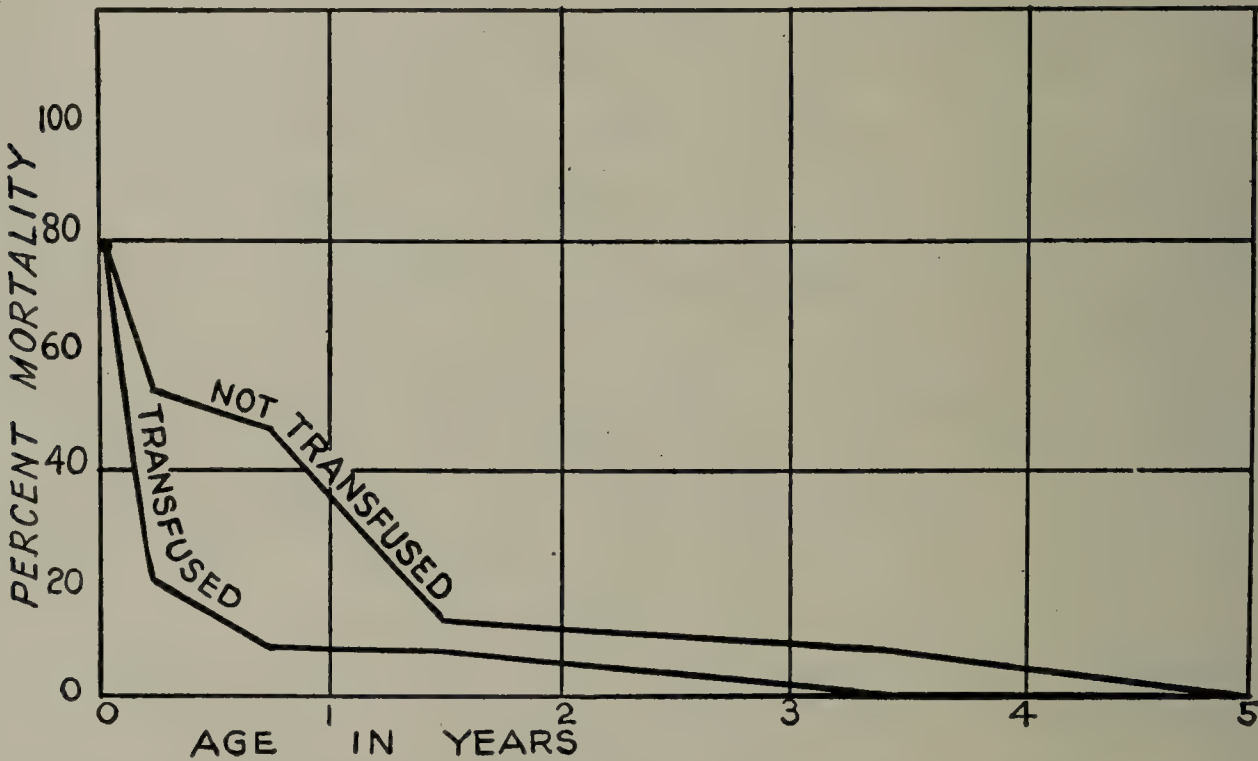


FIG. 196.—MORTALITY IN ERYSIPELAS AT DIFFERENT AGES (SCHAFER).

The graphs are based on 137 cases seen at the Harriet Lane Home, 55 of which were treated with transfusion, 82 by other means.

Irradiation of the affected areas with ultraviolet light, of an intensity just short of the vesicating dose, has given encouraging results at the Babies Hospital.

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## CHAPTER CXLI

### UNDULANT FEVER

This condition, also called Malta fever, an infection caused by *Brucella melitensis*, is rarely met with in children. Hardy, surveying all the reported cases in the United States up to 1929, found that only 7 per cent were in subjects less than fifteen years of age. It would seem as if children possess some natural immunity, for, in many communities where a contaminated milk supply has been discovered, adults rather than children have developed the disease.

In this country, the "abortus" strain of the organism—so called because it sometimes produces infectious abortion in cattle—is widespread. Many apparently healthy cattle harbor the organism and it is eliminated in the milk with great frequency. The majority of human infections appear to be milk-borne, though it seems that infection may take place from meat.

**Symptoms.**—The incubation period is not accurately known. There is great variability in the clinical picture, but in most instances the onset is insidious with fatigability, vague muscle pains, headache, difficulty in sleeping, sweating during sleep, chilliness, or possibly fever alone. Nausea and anorexia are unusual. The constitutional symptoms vary in severity. In the majority of cases the fever is of the remitting type, rising from normal or subnormal in the morning to a late afternoon level of 101° to 102° F.; it may pursue this course for two or three weeks with subsequent slow lysis by gradual descent of the peaks, or there may be waves of such hectic fever of from a few days to a few weeks' duration separated by remissions of similar indefinite length, the process gradually wearing itself out over the course of several weeks. The physical findings otherwise are meager and inconstant. The spleen and liver may be enlarged, joint pains of a rheumatic nature may occur, and in a few adults intermittent hydrarthrosis has been described. A mild leukopenia is the rule, with both relative and absolute increase of large mononuclear cells.

Agglutinins appear in the blood after the second week. A titer of 1:40 is suggestive, anything over 1:80 definitely positive. The agglutinins may persist, but have been known to disappear before symptomatic recovery. In a large proportion of patients the organisms may be recovered from the blood during the febrile periods; growth may not be evident before ten days to two weeks of incubation of the cultures, and often special technical methods are required. Organisms have been found in the stools. An intracutaneous test made by injecting a suspension of killed organisms may prove helpful in diagnosis.

Convalescence as a rule is slow, lasting from one to four months, and is attended by secondary anemia, loss of strength, fatigability, and failure to gain weight. Overexertion at this time may cause fever.

The prognosis is good. No deaths in children have as yet been recorded.



**Diagnosis.**—The main difficulty comes from failure to take undulant fever into consideration, and consequent omission of the specific tests. Most of the cases recognized up to the present have been identified in laboratories, to which the serum was sent for some other purpose. On account of the type of fever and the meagerness of other findings, the condition most often suspected is mediastinal tuberculosis. Typhoid and paratyphoid fever, septicemia, and malaria are often suspected, but the diagnosis cannot be confirmed by laboratory tests. Rheumatic fever and the disturbances due to focal infection may resemble undulant fever clinically. In any history of fever of undetermined origin, the possibility of undulant fever must be borne in mind. Some difficulty may arise in cases of tularemia, owing to cross-agglutination, but the higher titer for *B. tularensis* should settle the question.

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## CHAPTER CXLII

### TULAREMIA

Tularemia is an infectious disease caused by *Bacterium tularensis*. Primarily it is a septicemia of rodents, especially wild rabbits and hares. Secondarily it is a disease of man, transmitted by handling infectious material or by the bite of an insect or infected animal. Direct transmission from man to man is not known. Tularemia has been reported in all parts of the United States; it is most frequently found in those regions where it has been carefully searched for. It affects children less frequently than adults, for they have less opportunity of acquiring the disease.

The organism is a small, pleomorphic, gram-negative, non-motile and non-spore-bearing anaerobe. It seems able to penetrate the intact skin. The lesion of tularemia is a granuloma which may undergo necrosis; it may resemble tuberculosis very strongly. In septicemic cases lesions are found in the spleen, liver, lungs and sometimes other organs; there is often a central necrotic area in which polymorphonuclear cells are abundant; surrounding this is a zone of small round cell infiltration. Similar focal and diffuse lesions occur in the lymph glands and about the primary ulcers.

The average incubation period is three to four days, but may vary from one to ten days. Four clinical types are recognized: the ulceroglandular, oculoglandular, glandular and typhoid. In the first two the portal of entry is apparent. In most cases, and particularly in severe ones, the onset is sudden with headache, bodily pains, vomiting, malaise or prostration, chills and fever. In the ulceroglandular and oculoglandular types there is local pain and tenderness with swelling of the regional lymph nodes, although at first nothing may be noticeable at the site of entry. A day or so later a papule may form at the portal of entry and undergo necrosis and ulceration. Redness and sometimes lymphatic injection appears over the glands and in about half the cases suppuration ensues; in others there is a slow subsidence of swelling and induration over a period of two or three months. The ocular lesion seldom produces permanent damage to the eye. In the glandular type the picture is the same except for the absence of evidence of the portal of entry. The typhoid type shows only systemic symptoms, with no localizing signs whatever. Fever is constant in all types and pursues a characteristic course, with an initial rise of one to three days, a remission also of one to three days, and a secondary rise with slow subsidence to normal, the whole lasting from two to three weeks. A maculopapular or pustular eruption may appear at any time after the first few days in some part of the body, not necessarily near the primary lesion. There is sometimes moderate leukocytosis. Specific agglutinins are always present some time in the second week of the disease, and the maximum titer, which may be as high as 1:2560, is found between the fourth and the seventh



weeks. The agglutination reaction may remain many years after recovery. Cross-agglutination with *B. abortus* and *B. melitensis* is almost the rule, though usually the titer of these adventitious reactions is lower. Convalescence is slow, often requiring several months.

One attack confers immunity. The mortality up to 1928, reported by Francis, was 3.5 per cent. The treatment is symptomatic; incision of suppurating glands should be deferred until the condition of the overlying skin shows clearly that resolution is not to be expected.

Only a single instance of tularemia in a young child has been recognized at the Harriet Lane Home. The patient, a two-year-old girl, developed a low-grade fever and malaise with a red, tender swelling in the parotid region. Fluctuation was made out and the abscess was incised; the material was found to be caseous. Agglutination for *B. tularensis* showed a titer of 1:640. The adenitis persisted for several months, gradually subsiding. The patient made a complete recovery.

A history was subsequently obtained that the patient had been scratched in the face by a pet cat some days before the onset of the fever and that the scratches had not healed properly. The cat was not known to have killed rabbits. The father was a rabbit-hunter and rabbit skins hung on the walls of the house.

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## CHAPTER CXLIII

### TYPHOID FEVER

Typhoid fever may affect the fetus *in utero*, or the newly born child, and it is seen throughout infancy and childhood.

*Fetal Typhoid.*—When a pregnant woman develops typhoid fever, infection of the child *in utero* is a frequent but not an invariable occurrence. The fetal form of the disease is a general blood-infection, since the intestines are not functionally active. The most common result is death of the fetus and consequent abortion; but the child may be born alive still suffering from the infection. Death usually follows.

*Infantile typhoid* is a relatively rare disease. In over 14,000 admissions to the Babies' Hospital, New York, covering a period of thirteen years, but 11 cases of typhoid were recognized under two years of age and but 5 cases of one year or under, the youngest case observed being in a child eight months old. In Philadelphia, where there has been much more typhoid generally than in New York, Griffith reports under his personal observation or in the Children's Hospital 45 cases under two years and 9 under one year; his youngest cases were aged three, five, and nine months respectively. It is during epidemics that most of the infantile cases are seen, but even in epidemics it is surprising that so few infants are attacked.

*Typhoid in childhood* is by no means rare, but it is not until after the fifth year that it can be said to occur frequently. The following figures, embracing groups of cases reported by eight writers, represent the relative frequency with which the disease is seen at the different ages: of 970 cases, 8 per cent occurred under five years, 42 per cent between five and ten years, and 50 per cent between ten and fifteen years. In the Harriet Lane Home, among 215 cases of typhoid fever, 8 were under two years of age.

Typhoid fever is most commonly conveyed by carriers, rather than by patients who themselves are suffering from the disease. Only occasionally do epidemic outbreaks occur, suggesting a transmission through drinking water, milk, or other food. Even when such a mode of conveyance exists, infants are largely protected by the fact that most of the water and a large part of the cow's milk taken have been previously boiled, or heated in some manner.

**Pathology.**—In general the lesions resemble those of adults except in severity. In a considerable number of the cases the pathological process in the intestines does not go on to ulceration; when ulcers form they are seldom large or deep, and perforation is very rare. Autopsies made upon infants when the clinical diagnosis has been confirmed by bacteriological studies often show only a moderate redness and swelling of Peyer's patches, the solitary follicles and the mesenteric lymph nodes. In a doubtful case such postmortem findings do not establish



the diagnosis of typhoid. Indeed, they prove nothing unless cultures from the intestinal contents, the mesenteric glands, or other organs, show the typhoid bacillus. Enlargement of the spleen is practically constant. The degenerative changes in the heart, the kidneys, and the liver are much less frequent and generally less severe than in adults.

**Symptoms.**—The peculiar features of typhoid in early life are seen only in children under ten years old, for after this time the disease does not differ essentially from the adult type.

In infancy typhoid fever is not typical and often passes unrecognized. It may simulate dysentery and in hospitals the diagnosis is not infrequently made by the accidental discovery of typhoid bacilli in the stools. In other cases there may be no diarrhea or a transient diarrhea followed by constipation. The onset is sometimes insidious, but may be sudden; the temperature is irregular, usually reaching 104° F. at some part of the day; the duration is relatively shorter, seldom exceeding two weeks. Rose spots are said to be less frequent than in adults, but they were present in half of the cases seen in Baltimore; we have seen them so marked as to be the first symptom to attract attention. Nervous symptoms—although more conspicuous than intestinal manifestations—are rarely extreme and usually come late. The spleen can be felt in most instances.

A mild leukocytosis is about as common as leukopenia. The diagnosis is established by the recovery of typhoid bacilli from the blood or the stools, or by the Widal reaction. The mortality in infants is not high. Griffith reported a mortality of 12.5 per cent in 75 cases under two and one-half years observed by him. This is higher than in juvenile or adult typhoid largely because of the complication of dehydration. Other complications are rare, and there is little tendency for the disease to relapse.

Between the ages of two and ten years the mortality from typhoid is at its lowest, being between 2 and 4 per cent. The clinical picture resembles more closely that of the disease in adults, save that it is less severe. In most cases the onset is gradual, the fever rising to a fastigium in from two to seven days; then for several days it fluctuates within the limits of one to three degrees and gradually declines, reaching normal by the end of the third week. In a considerable number of instances, however, there is an abrupt onset with high fever, vomiting and perhaps convulsions. The average duration of the fever is shorter than with adults. In many cases it lasts less than two weeks; we have seen one child whose entire febrile period was only one week. The fever may be quite as high as in adults but there is usually less prostration. In the more severe cases there may be delirium at night, and meningismus is fairly common in the early stages. The slow, dicrotic pulse may be looked for in vain. There is no constant relation between the severity of the intestinal lesions and the condition of the bowels. Some diarrhea is present in only about half the cases. It is rarely profuse, from two to four discharges a day being the average. The stools are usually thin and fluid, often containing mucus, but are in no way characteristic. Sometimes there is abdominal tenderness and pain. Constipation may be present throughout the attack. Tympanites is generally moderate, and is often associated with iliac tenderness. By the end of the first week the spleen is usually palpable. Persistent



enlargement after defervescence is often a warning of impending relapse. In children rose spots are less constant than in adults, and tend to appear earlier. They appear chiefly upon the abdomen early in the second week, coming in successive crops, each of which generally lasts three days, the whole duration of the eruption being about ten days. We have seen them so numerous as to suggest measles. Loss of weight during the attack can rarely be prevented, and in prolonged cases there may be emaciation. At the beginning of convalescence a subnormal temperature is very frequent; in fact, it may be considered the rule. A secondary rise may be due to a relapse or to complications. Relapses occur in approximately 10 per cent of the cases and follow about the same course as in adults.

*Urine.*—A small amount of albumin is found in the urine of most of the severe cases at the height of the disease, but a marked degree of nephritis is infrequent. In fully one-fourth of the cases typhoid bacilli are found in the urine, generally in pure culture. They usually appear in the second or third week, and may continue for months or even years. They are sometimes accompanied by evidence of cystitis or nephritis. Their number is in some cases so large as to render the urine turbid. Ehrlich's diazo-reaction is invariably present at the height of the fever.

*Blood.*—The characteristic blood picture in typhoid is a leukopenia, generally under 10,000, accompanied usually by a slightly increased proportion of lymphocytes. Infants, however, may exhibit a leukocytosis. Blood cultures, with great uniformity, show the bacilli even in the first week of the disease. These usually have disappeared from the blood by the third week.

**Complications.**—The complications of typhoid in early life are infrequent and usually mild.

*Intestinal Hemorrhage.*—Of 946 collected cases, intestinal hemorrhage occurred in thirty; the majority of these were in children over ten years old; nearly half of those with marked hemorrhage terminated fatally. The youngest case of this nature which has come under our own notice was in a child of four and a half years.

*Intestinal Perforation.*—This is even more rare than hemorrhage. In 1028 collected cases, this occurred but twelve times. Perforation is indicated by a sudden fall in the temperature, with collapse; usually there is vomiting and the rapid development of tympanites with leukocytosis. In 6 out of 12 cases of perforation reported by Thompson a fatal outcome was averted by prompt surgical intervention.

Bronchitis is present in most of the severe cases; but pneumonia and pleurisy, both serous and purulent, are very infrequent. Cystitis, pyelonephritis, osteomyelitis, periostitis, and perichondritis may appear during the course of the disease or after defervescence. Meningitis is rare; in most cases the spinal fluid shows merely a pleocytosis, but the organisms are occasionally found. Morse has collected 21 cases of aphasia, in 2 of which it was clearly due to embolism; in the remainder, however, it apparently was not dependent on any organic lesion. It usually came on during convalescence, and terminated in complete recovery after a few weeks. We know of one instance in which the diagnosis of typhoid fever was made in



retrospect from the presence of this complication alone; it was confirmed by a positive Widal reaction. Psychoses are occasionally observed, the usual type being an acute mania of relatively short duration. Otitis is not infrequent and occurs much oftener than in adults. Other less frequent complications are: parotitis, which is usually suppurative and is seen in septic cases, noma, pericarditis, endocarditis, peritonitis, cholecystitis, suppurative arthritis, and furunculosis.

**Diagnosis.**—From clinical symptoms alone one may suspect the presence of typhoid fever, but a positive diagnosis requires confirmation in the laboratory.

The Widal reaction is present at some period in from 95 to 98 per cent of the cases, and thus constitutes the most valuable single diagnostic aid. It is seldom obtained before the seventh day and frequently not until the tenth or twelfth; it may not be present until convalescence or a relapse. For this reason it is of less value in early diagnosis than in verification. The typhoidin reaction has been little studied in young subjects.

Typhoid bacilli may be grown from the blood in almost all cases early in the disease, and in the great majority from the stools as well. They are found in the urine in about one-fourth of all cases.

A differential diagnosis is to be made from dysentery, paratyphoid fever, tuberculosis, undulant fever, malaria, and from other remittent fevers of obscure origin. The cerebral symptoms of typhoid may be difficult to distinguish from meningitis, and spinal puncture may be required for differentiation.

**Prophylaxis.**—Vaccination against typhoid is as effective in children as in adults. It should be undertaken whenever a child has been or is likely to be exposed to the disease. As a rule children show less constitutional reaction to the vaccine than do adults. The triple typhoid vaccine, containing paratyphoid A and B as well as typhoid organisms, is to be preferred. The usual preparation, containing 1,000,000,000 typhoid bacilli and a smaller number of paratyphoid bacilli per cubic centimeter, may be given to children of six years and over in the standard dosage of 0.5, 1, and 1 c.c. with a week's interval between injections. One-half these quantities may be given to children under two. There are no statistics available to show whether the duration of protection differs in young individuals from that in adults. Active immunization of this kind conveys merely a relative protection and does not justify any relaxation of normal hygienic measures.

**Treatment.**—In the great majority of cases very little active treatment is required. Every patient with typhoid should be put to bed and kept there during the febrile period and a few days beyond it, no matter how mild the attack may be. A liberal diet is strongly to be recommended; in fact, there is no reason to deviate from the child's normal diet in the average uncomplicated case. As a rule the quantity of food given should be gauged by the patient's appetite. Some children do better when small amounts are given at frequent intervals, others respond to an opposite policy.

Diarrhea occurring as a symptom of the disease may call for some modification of the diet. Constipation, sometimes fairly troublesome, may be relieved with mineral oil given by mouth or with an enema every second day; active purgation and the addition of bran to the diet are to be avoided.

High fever is not in itself dangerous, but if it is accompanied by discomfort



and restlessness or by delirium it may be lowered by a cool sponge bath, an alcohol rub, or irrigation of the colon. Tubbing is to be condemned.

Isolation must be rigorous. Gowns should be provided for those who come in contact with the patient, and facilities for washing the hands both before and after removing the gown. As a sterilizing fluid for instruments and for linen preparatory to boiling, lysol is perhaps the most convenient. Paper napkins and towels, which can be collected in paper bags and burned, are a great convenience. Both the urine and feces should be thoroughly mixed with strong lysol solution or formalin and allowed to stand for an hour before being discarded.

Bacilluria during the course of the disease is to be expected and calls for no special treatment, but if it persists into convalescence it may be combated by the administration of hexamethylenamin (urotropin), from 3 to 5 grains three times a day; the urine must be rendered acid at the same time by administration of ammonium chloride or acid sodium phosphate.

Quarantine regulations differ slightly in various communities. In the majority, stool and urine cultures for release may be taken a week after the temperature has dropped to normal, and isolation discontinued only after two negative cultures of both urine and feces, separated by at least twenty-four hours, have been reported.

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## CHAPTER CXLIV

### PARATYPHOID FEVER

This disease is less common than true typhoid, but isolated cases and small epidemics appear from time to time, due usually to paratyphoid B which, in this country at least, is much more common than paratyphoid A. There is no clear clinical distinction between the two. Some of the cases behave like mild and atypical typhoid fever, with a shorter duration and with less marked general and local symptoms. Others run a short but rather violent course, with fever, vomiting, and diarrhea; this is particularly likely to be the case with household or school outbreaks of "acute indigestion" traceable to contamination of food. On the other hand, the symptoms of the original infection are sometimes so mild as to be missed entirely and the diagnosis is made only when the organisms are recovered as the result of some complication. Thus, we have seen cases of pyuria, of osteomyelitis, and of suppurative arthritis in young infants, from which paratyphoid B organisms were recovered locally and in which no definite history of antecedent infection could be elicited. Involvement of the bones is more common in paratyphoid than in typhoid infections. We have seen one case in which practically all of the bones, except the skull, were implicated at intervals during a period of two months.

Some cross-agglutination with typhoid bacilli is often obtained, but a higher titer is always found with whichever paratyphoid strain is responsible for the infection. Stool and urine cultures should be made exactly as in typhoid fever. Not many autopsies have been reported after infection with these organisms; but in general the lesions do not differ markedly from those of true typhoid.

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## CHAPTER CXLV

### DYSENTERY

The term dysentery is a general one, embracing those forms of intestinal disease in which true inflammatory lesions are present in contrast to the nonspecific forms of diarrhea described elsewhere in which nothing more than superficial changes occur. Although an identical clinical picture may at times be produced by other organisms, particularly those of the typhoid group and, rarely, *B. pyocyaneus* or the tubercle bacillus, the overwhelming majority of cases are due to the dysentery bacillus, and it is to this infection that the ensuing discussion is limited.

**Etiology.**—Although dysentery is seen with especial frequency in summer, and in children under two years old, it may affect those of any age, and occurs at all seasons. Epidemics are not uncommon in the early fall months. While usually primary, dysentery occasionally follows infectious and other diseases. It frequently occurs in institutions, chiefly as a terminal infection in infants suffering from extreme malnutrition or marasmus. All other forms of intestinal disease are predisposing causes. In epidemics a common origin of cases is apparently more frequent than the spread of the disease from one patient to another.

The dysentery bacillus, or, more properly speaking, this group of closely allied organisms, has now been found in all parts of the world in a sufficient number of cases to establish its etiological connection with dysentery. *B. dysenteriae* was shown by Shiga, in 1898 and 1899, to be the cause of epidemic dysentery in Japan. In 1900, Flexner established its association with dysentery in the Philippines, and in 1902, Duval and Bassett, pupils of Flexner, demonstrated its presence in a series of cases of dysentery in children at Baltimore.

The organism is most easily recovered from the blood-streaked mucus characteristically found in these stools. It is generally greatly outnumbered by other organisms and is never found in pure culture. A number of minor differences have been found in the bacilli from different cases; there are, however, two main groups, the division being made on the basis of mannite fermentation. Dysentery bacilli that do not ferment mannite form the Shiga group. The mannite-fermenting organisms are divisible into several subgroups, depending upon cultural and serological reactions. They are often spoken of, at the present time, as the subdivisions V, W, X, Y, and Z of the Flexner group. Organisms of the Flexner group are responsible for over 80 per cent of the cases of dysentery in children in this country. In Baltimore 94 per cent of the infections in children have been due to the Flexner type.

The portal of entry of the infection cannot be definitely stated. *B. dysenteriae* has never been found outside the body except in stools and rarely in urine. Contamination of a food supply would seem the most likely explanation for the development of a large number of cases at one time. Isolated cases very probably



owe their origin to infection by a carrier. The incubation period is usually between four and five days, although it may be from one to eight days.

The rôle played by other bacteria, especially streptococci, in the production of the deeper lesions of the intestine in prolonged cases may be an important one. This appears, however, to be rather in the nature of a secondary invasion.

**Pathology.**—The disease involves chiefly the colon. The cecum and first portion of the ascending colon, and the sigmoid are more commonly involved than the transverse portion. In less than half the cases the lower ileum is affected, usually for a distance of about fifty centimeters, and always the lesion is less advanced than in the colon.

The lesion consists at first in a diffuse inflammation of the mucosa, without any tendency to localization in the lymphoid structures. In the early stages the mucosa is swollen and reddened. The vessels are dilated, and punctate hemorrhages are present. The secretion of mucus is increased. At this time microscopic sections show hyperemia and infiltration with inflammatory cells, both polymorphonuclear leukocytes and mononuclear cells. The crypts often contain leukocytic exudate. The submucosa is usually slightly edematous and there are more cells than usual, often mainly mononuclear cells with few polymorphonuclear leukocytes.

As the process advances the more prominent portions of the mucosal folds are found to be more deeply reddened, and flecks of yellow opaque membrane appear to become confluent along the crests of the transverse folds. In a longitudinal direction the more flattened strips of mucosa produced by the taeniae are more affected than the pouches between them. The formation of opaque, dry, yellowish diphtheritic membrane may extend to involve the whole mucosal surface in diffuse fashion, but usually it sloughs away in smaller or larger portions to produce irregular shallow ulcers. In our experience the severe diphtheritic forms are more commonly produced by Shiga infections. The whole intestinal wall is thickened and stiffened; swelling of the submucosa is obvious on cross section. Beneath the membrane a dark red hemorrhagic zone is visible. Microscopically the membrane is made up of fibrin, débris of cells of the exudate, and the dead coagulated mucosa itself. It may involve only the superficial layers, leaving the deeper portions of the crypts intact, or involve the whole mucosa. There are hemorrhages into the underlying, not yet necrotic, tissues, which are infiltrated with inflammatory cells—polymorphonuclear leukocytes and mononuclear cells. The inflammatory reaction in the submucosa is now much more marked than in the early stages. Ulceration usually stops at the submucosa, but the muscularis mucosae may be destroyed, and sometimes the muscular layers are exposed. Perforation is very uncommon. Ulceration is usually not pronounced before the second to third week.

In the more protracted cases the ulcers are lined by a pink, satin-like membrane, sometimes difficult to distinguish from mucosa, and in section this is found to be a layer of granulation tissue densely infiltrated with mononuclear cells. Plasma cells are often quite conspicuous. New growth of epithelium can be seen at the margins of the ulcers. The intervening mucosa is swollen but paler, and the intestinal wall is still thicker and stiffer.

The mesenteric lymph nodes are rarely more than slightly enlarged. The sinuses



may contain more cells than usual, including red blood cells in small quantity. Phagocytosis of these and fragments of other cells by large mononuclear cells is sometimes present but not conspicuous. The spleen is not involved.

*Associated Lesions of Dysentery.*—The most important one is pneumonia. It is found in quite a large proportion of the protracted cases, and is not infrequently the cause of death. It is usually an interstitial bronchopneumonia caused by streptococci or influenza bacilli. Tuberculosis is not infrequently met with in hospital cases, having no relation to the intestinal disease. Peritonitis is infrequent. We have met with it but once or twice, and then it was localized and of the plastic variety. Inflammations of the other serous membranes are very rare.

A general blood infection with dysentery bacilli as shown by blood cultures is very rare.

Aside from cloudy swelling, the kidneys in dysentery are found to be normal. We have seen a slight amount of tubular damage with occasional small foci of necrosis and calcification in a few instances. This is in no sense to be regarded as a specific lesion, for it is found in other conditions in childhood.

**Symptoms.**—*Mild Cases.*—Occasionally very mild forms of dysentery are met with, which show only slight fever and soft mucous stools for a few days. The constitutional symptoms are not at all marked. The temperature may not be above 101° F.; the tongue may remain clean and the appetite good; the child may be bright and active, and hardly seem at all ill, and yet have from six to eight mucous and bloody stools a day. We recall one case in which the temperature did not exceed 100° F. and there was a mild diarrhea lasting only two days. A routine stool culture revealed the presence of the Shiga bacillus. Such experiences are, however, unusual. Nearly always the dysentery bacillus declares its presence by producing marked constitutional symptoms and a bloody diarrhea.

*Cases of Moderate Severity.*—The onset is usually sudden, often with vomiting, and for twelve, sometimes twenty-four, hours the symptoms may be those of simple diarrhea: vomiting, pain, fever, and frequent, thin, green or yellow stools, which are partly fecal and contain undigested food. The loss of water is often very great in the early stages. Later the discharges contain blood and mucus, are often preceded by pain and accompanied by tenesmus. The stools are very frequent, often every half hour, and proportionately small, sometimes less than a tablespoonful being found upon the napkin after severe straining efforts. The mucus may be clear and jelly-like, or it may be mixed with fecal matter. Blood is seen in some cases in almost every stool, usually streaking the mucus, but rarely in clots. These stools are almost odorless. The claim has been made, however, that experienced observers can detect a dysentery stool by its odor. After a few days the blood usually disappears, or is seen only as traces in an occasional stool; but mucus is still present in large quantities, sometimes containing so many leukocytes as to appear like pus. The color of the discharges now becomes dark brown or brownish-green. Prolapsus ani is frequent, and may occur with nearly every stool. Abdominal pain is present, and is often quite intense just before the stool; frequently there is tenderness along the colon. For the first twenty-four hours the temperature is usually high, from 102° to 104° F. During the greater part of the attack it ranges from 99° to 102° F. A leukocytosis may or may not be present;



as a rule it does not exceed 15,000. There is considerable prostration; the loss in weight is usually marked and continuous; appetite is poor; the tongue is coated and the general appearance of the child indicates serious illness, although no really grave symptoms are present. Convalescence is always slow, and it may be weeks before the appetite and lost weight are regained.

The duration of the acute symptoms is usually two weeks; yet in such cases, even though the child was previously in good condition and properly treated, recovery is slow. The first sign of improvement is generally the disappearance of blood from the stools, which at the same time become less frequent, and the pain and tenesmus cease. Gradually the stools assume more of a fecal character, but mucus is likely to persist for two or three weeks; it may be seen in all stools, or only occasionally. In some cases both the mucus and blood disappear and the stools become thin, brown, or green, like those of ordinary diarrhea. Relapses are readily excited, but cases such as have been described are rarely fatal except in delicate infants. Relapses may not necessarily be due to a recrudescence of the infection. Sometimes the intestine remains hyperirritable for many months after an attack, and very minor dietary indiscretions may lead to a diarrhea with much mucus, but without dysentery organisms demonstrable in the stools. This is the most common form of dysentery which terminates in recovery.

*Severe Forms.*—The disease begins abruptly with vomiting, high fever and a few hours later several large, fluid stools. The vomiting does not often continue after the first twenty-four hours. The temperature is at first from 102° to 105° F. and its course is usually steadily high, though it may be remittent. The stools are very frequent and soon contain blood and mucus. The only positive proof of membranous inflammation is the presence of shreds or flakes of pseudomembrane. If the stools are thoroughly washed with water these may be seen as small, gray, opaque masses, which may be distinguished from the transparent mucus. Large shreds of membrane are seldom seen in children. In very rare instances, in older children especially, a spastic or thickened colon may be felt through the abdominal wall. The abdomen is often tender and sometimes distended. There is severe pain and often tenesmus, with prolapse of the rectum. This is intensely congested and occasionally patches of pseudomembrane may be seen upon its surface. Examination with the proctoscope may reveal the presence of false membrane in the rectum, or ulceration. Both blood and mucus sometimes disappear from the stools, which may consist only of colored fluid. There is great prostration, dry tongue, sordes on the lips and teeth, and there may be prominent nervous symptoms. Acidosis due to acetone bodies may develop rapidly. The presence of cerebral symptoms in cases of severe dysentery may lead to great obscurity in the diagnosis. This is most frequently true at the onset. There may be high temperature, great prostration, vomiting, stupor, delirium, and even convulsions; and such symptoms may for two or three days completely mask the intestinal condition. As the case progresses, however, the intestinal symptoms come more and more into prominence, and the cerebral symptoms usually subside.

Dysentery is also obscure when it affects young infants. The prominent symptoms are: rather high, continuous temperature, usually ranging between 101° and 104° F., but following no distinct curve (Fig. 197); wasting, which is not rapid



but progressive; frequent stools, which have no constant or striking characteristics. They are usually thin, yellow or greenish in color, often containing no mucus or blood. Occasionally for a day the stools may be almost normal in appearance. In number they average five or six a day, but often for days only two or three. Outside of a hospital where autopsies are regularly made, these cases are often overlooked and considered as obscure pneumonia, tuberculosis, septicemia, typhoid, etc.

The duration of severe dysentery is usually from a few hours to several weeks. The duration of the most rapidly fatal case we have seen was only eighteen hours. We have seen one child recover after thirty-eight days of continuous fever. The

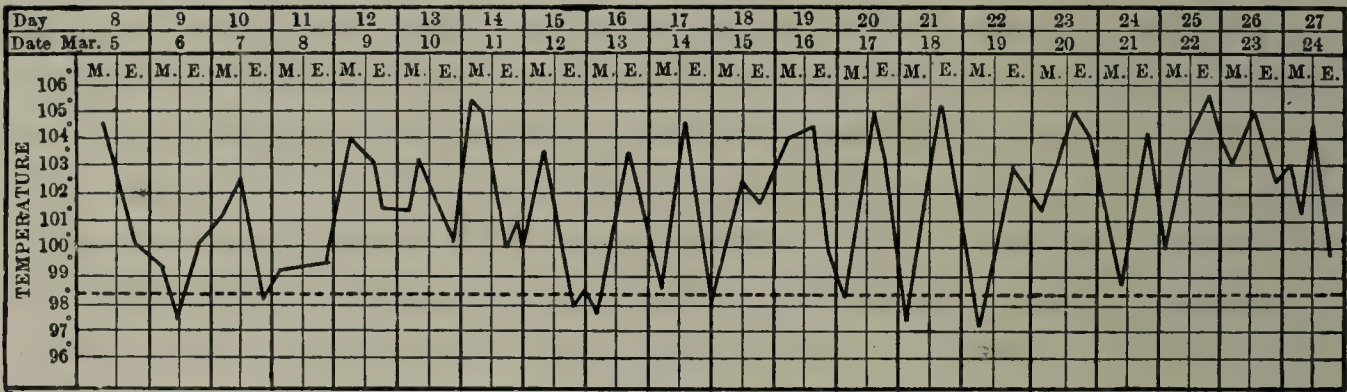


FIG. 197.—TEMPERATURE CHART IN FATAL CASE OF DYSENTERY.

Infant fourteen months old, Babies' Hospital. Symptoms for the first two weeks obscure. Intestinal symptoms for the last two weeks only, never very severe; stools four to six daily, geerally green, thin, with much mucus at times, and once or twice traces of blood. *Autopsy*: Membranous dysentery involving entire colon; catarrhal enteritis.

usual duration of acute symptoms is ten to twenty days. Death usually occurs when the symptoms are at their height, the children apparently being overwhelmed by the severity of the disease; or, the acute stage having been survived, they succumb to exhaustion or to some intercurrent infection such as pneumonia. It is probable that almost every case of the severity described terminates fatally when it occurs in a young infant.

In older children the disease is usually milder and the prognosis is much better as to life, but in them the acute attack may be followed by a prolonged convalescence or by persistent intestinal disturbances. Some cases of chronic intestinal indigestion (celiac disease) apparently owe their origin to an attack of dysentery.

*Chronic Ulcerative Colitis*.—In institutional practice and occasionally with very poorly nourished infants a type of dysentery is seen which is marked more by its chronicity than by its severity. The patient has often had several previous attacks of diarrhea or a prolonged subacute attack. The onset is usually not abrupt and the fever does not remain high. Toward the close, even of fatal cases, it may be hardly above normal. Vomiting is not a feature of these cases, though it may be easily excited by injudicious feeding. The stools are seldom very frequent but contain large quantities of mucus. Blood is not usually present.

The failure in nutrition and steady loss in weight are very constant in these cases. As emaciation goes on, the skin hangs in loose folds on the thighs; it becomes dry and scaly and loses its elasticity, and occasionally small petechial spots



are seen upon the abdomen. The skin over the buttocks becomes excoriated, and bed sores form over the heels, the sacrum, or the occiput. The abdomen may be moderately distended, or it may be relaxed and soft. Tenderness is not usually present. The appetite is lost, and in most cases great difficulty is experienced in inducing these children to take a proper amount of nourishment. The mouth is often dry, the tongue coated, sometimes dry and brown; there may be sordes upon the lips and teeth. Superficial ulcers form upon the mucous membrane of the mouth, and often thrush is seen. Prolapsus ani is not uncommon.

Patients with these symptoms are very likely to have follicular ulceration of the intestines, especially the colon. If a delicate infant who has previously been prone to diarrheal attacks has low fever and stools with much mucus and if these symptoms persist for three or four weeks with steadily failing strength and loss of weight it is safe to assume that ulceration is present.

The usual duration of the fatal cases is three or four weeks, but may be very much longer; their course is often marked by exacerbations and remissions. If recovery takes place, convalescence is always very slow and relapses are easily excited. Many of these cases recover completely in time, if they are carefully handled.

**Diagnosis.**—Dysentery is to be distinguished chiefly from nonspecific diarrhea, typhoid fever, intussusception, and meningitis. From nonspecific diarrhea dysentery is distinguishable by its sudden onset, by the more marked constitutional symptoms and by the presence of blood and pus in the stools. Often, however, one remains in doubt until specific bacteriological information is available. Typhoid is distinguished by the slower invasion, more regular fever, enlargement of the spleen, and most of all by the presence of typhoid bacilli in blood culture or by a positive agglutination reaction.

Dysentery should not be confounded with intussusception; yet the records of intussusception show that a very large proportion of the cases were regarded in the beginning as cases of dysentery. In intussusception, although there is a sudden onset with acute pain, tenesmus, vomiting, and marked prostration, there is rarely fever. The later symptoms—absolute constipation, tumor, stercoraceous vomiting, and collapse—have nothing in common with dysentery. Dysentery may at times be confounded with meningitis, and in some cases a differential diagnosis is impossible except by lumbar puncture. Marked diarrhea, even though the stools are not characteristic, should always make one doubt the existence of meningitis.

An agglutination reaction of *B. dysenteriae* with the serum of affected children is usually present in from ten to fifteen days after the onset of symptoms. For general use in diagnosis this is not of great assistance, unless made with standardized cultures; then it may be of great value. Agglutinins persist in the blood from four to six months after an attack, rarely longer than this. Second attacks are exceedingly rare, and it seems likely that most patients remain immune even after their serum has lost the specific agglutinins. In most of the recorded instances of second attacks a different type of dysentery bacillus was responsible.

**Prognosis.**—As a rule, the younger the patient the worse the outlook; however, some of the mildest atypical attacks we have seen were in young patients. The prognosis is rendered unfavorable by extreme summer heat and by prolonged



previous attacks of intestinal disturbance. The outlook is worse in secondary than in primary cases. In a given case bad prognostic symptoms are: continuous high temperature, the persistence of much blood in the stools, and severe nervous symptoms. The prognosis is always worse in institutions than in private practice. The mortality even in well-conducted hospitals is at least 25 per cent.

Shiga infections have in our experience been more severe than those of the Flexner group; the difference, however, is not great. Of 26 cases of Shiga infections of which we have records the mortality was 50 per cent, whereas in a larger group of Flexner infections only 30 per cent died. Other observers have failed to find any clinical differences between the two types of infection. In Japan the Flexner infections are said to be the more severe of the two.

**Prophylaxis.**—What has been said in a previous chapter regarding the general prophylaxis of diarrheal disease applies equally well to cases of dysentery. Of particular importance in the prevention of dysentery in infants are: cleanliness of food, protection from flies, avoidance of adults with a mild diarrhea of any kind, and avoidance of summer heat if possible.

Some progress has been made with prophylactic immunization with dead bacilli. There seems to be little doubt that an immunity lasting for several months can be produced. Dysentery vaccines, however, are highly toxic, and although this toxicity can be decreased by combining vaccine with immune serum, it must be admitted that a safe and effective method is not yet available.

**Treatment.**—The proper control of dehydration is usually the most immediate concern in the treatment of dysentery. This has been discussed elsewhere (*vide* Diarrhea). In feeding these patients one should free one's mind from the view that the character of the stools indicates the condition of the patient's digestion. The diarrhea may be only the result of the inflammatory process. On the other hand, an attack of dysentery may depress the digestive functions exactly as does a parenteral infection, and a temporary period of starvation may be beneficial. It is our practice to begin with a brief period of starvation but to increase the food fairly rapidly and then maintain an adequate intake regardless of the character of the stools. Acidified milk appears to be advantageous for infants.

The appetite may totally fail in prolonged febrile cases and even after subsidence of the fever, in patients who are very weak. It is then necessary to feed by gavage, employing small quantities of concentrated food. Gavage may be necessary for only a few days but sometimes for a week or more.

For older children the diet may be the same as in any acute febrile illness; the proportion of fat in the food should not be high. Citrus fruits are likely to be badly borne; bananas, however, are usually well tolerated. For months after an acute attack the intestines are very easily deranged. Relapses are excited by changes in the temperature, by great fatigue or exhaustion, but most of all by improper feeding.

Opium is usually required on account of the pain, tenesmus, and great frequency of stools. The dose should be regulated by the severity of these symptoms. The deodorized tincture and paregoric are, we think, preferable to other preparations. Repeated small doses are better than a single large dose. Severe



tenesmus, when associated with prolapsus ani, is sometimes immediately relieved by a suppository containing cocaine. Not more than  $\frac{1}{4}$  grain should be used for a child of three years.

Repeated colon irrigations or astringent enemata are undesirable. Cases are not infrequently seen in which such measures have been an important factor in keeping up the production of mucus.

Specific treatment with antidysentery serum or with bacteriophage has proved disappointing.

Removal from the heat of a city is desirable as soon as fever and acute inflammatory symptoms have subsided. In the protracted cases which drag on with a subacute course, this change will often do more than anything else.

Although dysentery carriers following an attack are decidedly rare as contrasted with typhoid carriers, this possibility must be borne in mind. We have seen one boy who carried Flexner bacilli for several years, during which time he had only mild occasional attacks of diarrhea. The treatment of carriers is unsatisfactory.

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## CHAPTER CXLVI

### AMEBIC COLITIS

Amebic colitis is rare in children in this country; it is particularly so in infants. Most of the cases in children thus far reported have been observed in warm climates, although Amberg has recorded five which occurred in Baltimore, the youngest child being two years and eight months old. The pathology does not differ from that in adults.

The symptoms in the few cases that have been reported in children have differed in no important particular from the disease as seen in adults. In exceptional instances the onset may be abrupt and the attack may run an acute course, terminating fatally in two to three weeks. Such cases are characterized by abdominal pain and tenderness, frequent mucous and bloody stools, and fever, which, however, seldom reaches 102° F.

More frequently this acute onset is followed by a subacute or chronic form of the disease, or the condition may be subacute from the beginning. The protracted cases are those most frequently seen. They are very obstinate to treatment. Periods of constipation and apparent recovery often alternate with exacerbations, in which the bloody and mucous stools return with pain, tenesmus, and slight fever. The duration may be from a few months to one or two years. Death may finally occur from exhaustion with extreme wasting, or from some complication, such as hemorrhage; abscesses of the liver are rare in children.

The diagnosis from other forms of colitis is made only by the discovery of pathogenic amebae in a freshly voided stool. Characteristically, *Endamoebae histolyticae* appear in the stools in "showers"; several successive discharges will show no organisms, or at most a few cyst forms, then suddenly a stool will be found swarming with actively motile amebae, some of which contain red blood cells. The organisms remain viable and morphologically typical in a fleck of mucus or blood for some time after they have disintegrated and disappeared from the fluid portion of a stool. In a doubtful case repeated examinations are required before one can rule out amebiasis with any degree of certainty.

The proctoscopic picture is characterized by scattered ulcers which resemble the oral lesions of aphthous stomatitis, with normal-looking intervening mucous membrane. Fibrin and necrotic material in the crater of the ulcer bring its level flush with the surrounding surface. When this fibrin plug is removed, the base bleeds profusely. Amebae are often demonstrable in such a plug when not readily found free in the stools.

Specific treatment with emetin usually causes a prompt abatement of symptoms. It is best given intramuscularly in the form of the hydrochloride, from  $\frac{1}{10}$  to  $\frac{1}{5}$  grain (6 to 12 mgm.) being suitable for a child of three. Emetin may also be given by mouth, in somewhat larger doses, but is then more likely to cause vomiting.



It is difficult to administer sufficiently large doses of ipecac (from 1 to 2 grains) to a child without inducing vomiting, though this may be accomplished by the use of salol-coated pills. Other drugs which have been found helpful, particularly in recurrences, are yatren (iodoxyquinolin sulphonic acid); spirocid (acetarsone), and bismuth iodide. Symptomatic treatment with morphine and colonic injection of quinine in solutions of 1:5000 to 1:250 may be required. General hygienic measures should not be neglected. Relapses are exceedingly common.

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## CHAPTER CXLVII

### MALARIA

Malaria is an infectious disease due to the presence in the blood of a specific organism, the *Hematocytozoön malariae*. It manifests itself in children by acute febrile attacks such as are seen in adults and by chronic malarial infection.

**Etiology.**—The malarial organism was discovered by Laveran in 1881; it enters the blood through the bite of a mosquito belonging to the genus *Anopheles*, and, as a rule, in no other way. We have recently seen a case in which the infection was conveyed by a blood transfusion. For a general discussion of the malarial parasite, the reader is referred to works on clinical microscopy.

Malaria affects all ages, even the newly born infant. We must accept with some allowance the statements made by the older writers upon the subject of intra-uterine infection, but in the following case reported by Crandall, there seems little doubt that the disease was contracted *in utero* or at the time of the separation of the placenta: The mother had suffered from an intermittent tertian infection of moderate severity for ten days before delivery. Eighteen hours after birth the child was noticed to have cold hands and feet, blue lips and nails, and a pinched face. These symptoms lasted about half an hour and were followed by a distinct fever. Upon the following day the paroxysm was repeated. Examination of the blood of the mother and the child revealed malarial organisms in both cases.

Malaria is more frequently overlooked in young children than in later life, from the fact that its forms are more irregular, and this has led to the belief that young children are less liable than adults to the disease. This is, however, doubtful. In a large number of instances where families have been exposed to malarial infection we have noted that the young children were frequently the first to develop it.

Opportunities for study of the peculiarities of the lesions of malaria in children are infrequent, especially in New York and Baltimore, as fatal cases are extremely rare. We have seen but two. As observed by others, the lesions do not differ in any marked way from those of the adult form of the disease.

**Symptoms.**—The clinical forms of malarial fever in children from six to ten years old do not differ essentially from the same disease in adults. Both tertian (Fig. 198) and estivo-autumnal (Fig. 199) attacks occur with considerable frequency, the former being the type most often seen. Double tertian infection (Fig. 200) is not uncommon but along the middle Atlantic coast the quartan type, unless imported, is unknown. The stages of the paroxysm are generally well marked. The cold stage begins with a chill or vomiting, with headache, lassitude, and general pains. The hot stage is usually characterized by a higher temperature than in adults, and this is followed by the sweating stage, which is



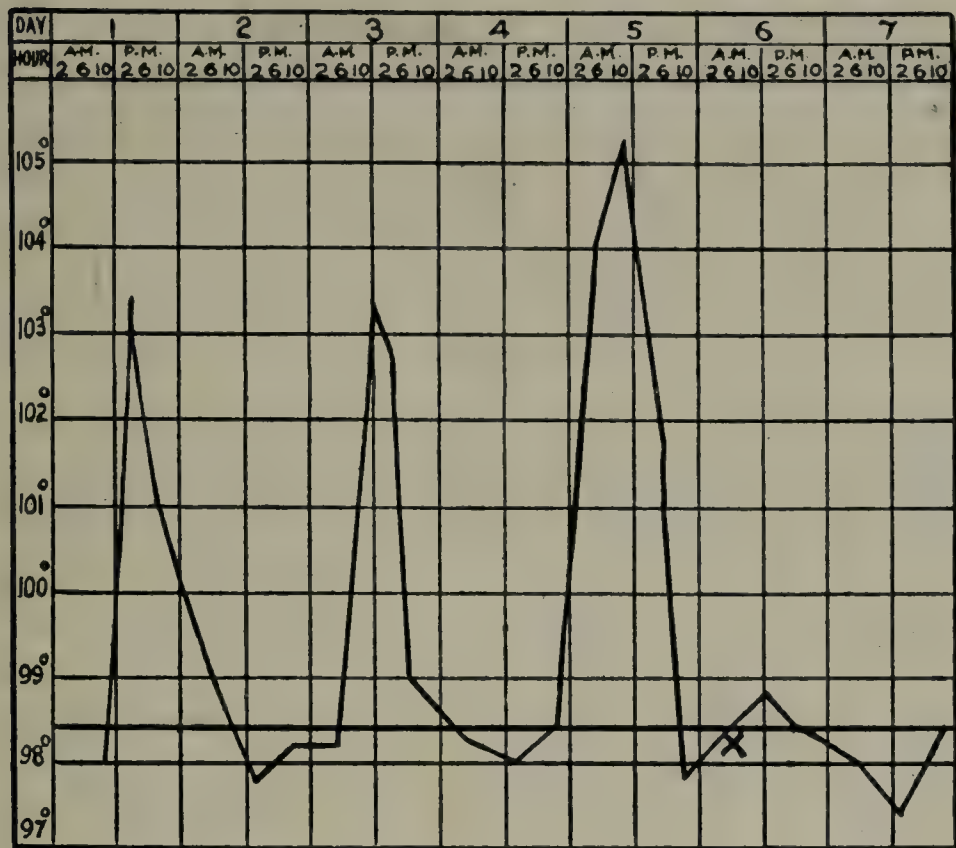


FIG. 198.—TYPICAL MALARIAL TEMPERATURE, TERTIAN TYPE, IN A BOY FIVE YEARS OLD.

Onset with vomiting and drowsiness, but no chill. This was an anticipating tertian, the first paroxysm occurring at 3 P.M., the second at 12 M., the third at 10 A.M.; X marks the time when quinine was begun.

generally marked. The paroxysm may be repeated every other day or every day, depending upon whether there is a single or double tertian infection, until controlled by quinine. Less frequently there is an estivo-autumnal infection and the fever is remittent from the beginning and the constitutional symptoms are of greater severity.

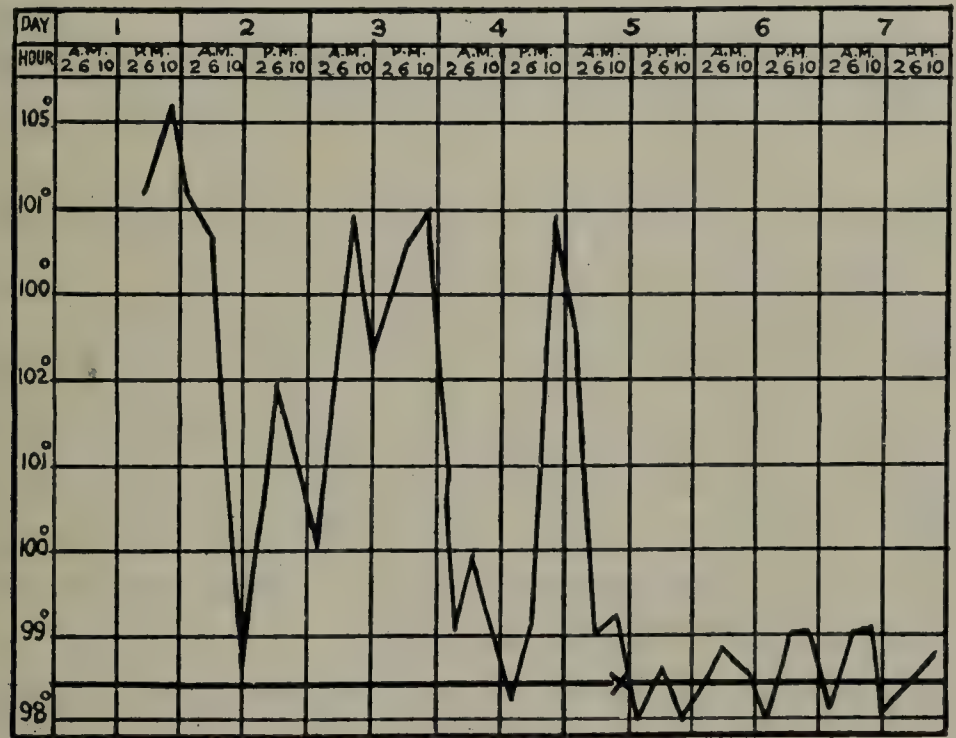


FIG. 199.—AN IRREGULAR MALARIAL TEMPERATURE (DUE TO ESTIVO-AUTUMNAL INFECTION) IN A CHILD NINE MONTHS OLD.

The paroxysm on the fourth day was accompanied by an attack of acute pulmonary congestion which came near being fatal; X marks the time when quinine was begun. Although the course of the temperature is irregular, it touched the normal line on both the second and fourth days.



In infants and very young children peculiar types of malaria are seen. A well-marked intermittent fever with distinct stages is often absent, many cases assuming more of a remittent type, or an irregular intermittent form. The onset is usually abrupt with vomiting, a well-marked chill being rare. Malarial chills are not often witnessed in children under five years old. They are replaced in infants by cold hands and feet, blue lips and nails, sometimes slight general cyanosis, pallor, drowsiness, and prostration. Vomiting has been present in two-

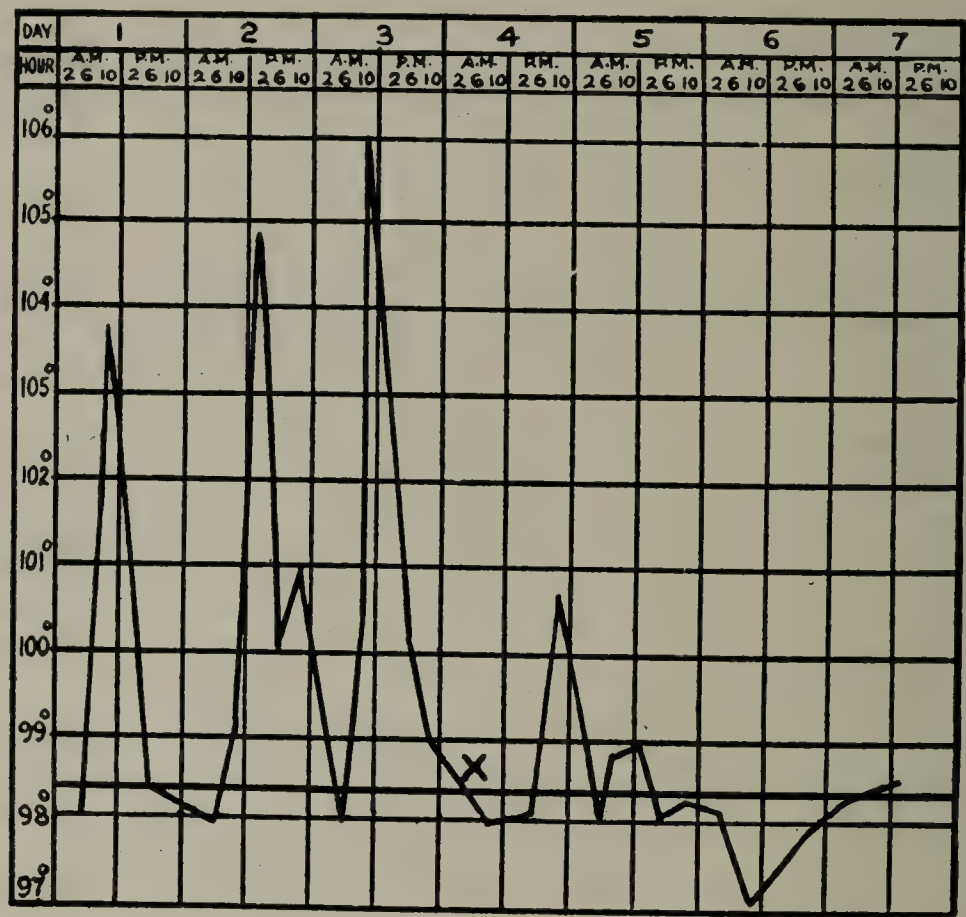


FIG. 200.—TYPICAL MALARIAL TEMPERATURE, DOUBLE TERTIAN TYPE, IN A BOY SIX YEARS OLD.

Each paroxysm preceded by a chill. It will be noticed that the temperature rose higher with each succeeding paroxysm; X marks the time when quinine was begun.

thirds of our own cases. Several times we have seen a malarial attack ushered in by convulsions.

The fever is relatively higher than in adults, rising rapidly to 104° or 105° F., occasionally to 106° or 106.5° F. This continues from four to twelve hours and gradually falls, usually to normal. The other constitutional symptoms of the febrile stage are much less severe than in most diseases with the same elevation of temperature. The sweating stage is only slightly marked and is often absent altogether. With the fall in the temperature there is a gradual subsidence of all the other symptoms of the febrile stage.

After the first paroxysm the patient may be quite well for several hours or even for a day, when the second paroxysm occurs. This is generally not so well marked as the first one, the third may be even less so, and the case may resemble more and more one of continuous fever with wide oscillations in the temperature. In some cases it is remittent at first and later becomes intermittent, but it is very rare in any circumstances that the temperature does not touch the normal point at some time in the twenty-four hours.



Enlargement of the spleen is present in the great majority of cases, and usually to a sufficient degree to be readily appreciated by examination. None of the other symptoms occurring in malarial fever are characteristic; they are quite similar to those which are seen in almost all febrile attacks. They are anorexia, coated tongue, constipation, and restlessness. There is usually a moderate degree of secondary anemia; the white count is variable but there is a distinct tendency to lymphocytosis.

*Masked or Irregular Forms of Malaria.*—These are quite frequent in young children, and are due to the presence of certain special or uncommon symptoms which may readily lead to a mistake in diagnosis. They are more often seen than cases of true malarial cachexia.

Among the most frequent of the irregular forms are those relating to the nervous system. Headache is exceedingly common and is usually frontal. Vertigo is not a frequent symptom, but it is sometimes prominent. Pains in various parts of the body are common. A sharp, severe pain at the epigastrium is frequent at the beginning of a paroxysm. It is often associated with tenderness. Less frequently pain is localized in the region of the spleen or liver. Aching or dragging pains in the muscles of the lower extremities are frequent symptoms during acute attacks, but may be of short duration, disappearing with the fever. The pain is accompanied by tenderness of the muscles and nerve trunks, and by loss of power, which is usually partial.

Accompanying the paroxysms of malaria there is occasionally seen, more often in infants than in older children, pulmonary congestion or edema of the lungs (Fig. 199) which may give rise to obscure and often very alarming symptoms. There is an acute onset with vomiting and prostration, high temperature, cough, rapid respiration, and often slight cyanosis. On examination of the chest there is found feeble or rough respiration over one lung, or over both lungs behind, and numerous coarse moist râles; these signs and symptoms may disappear in the course of a few hours with the fall in temperature, to return with the next paroxysm, or if quinine is given they may disappear entirely.

*Subacute or Chronic Forms of Malaria.*—The most constant symptoms are anemia, enlargement of the spleen, and slight fever. The anemia is usually marked, often being extreme. The enlargement of the spleen is distinct, easily made out by palpation, and sometimes is very great. The fever is often so slight as to be discovered only when the temperature is taken five or six times in the twenty-four hours. The other symptoms are of a very indefinite character; there may be slight edema of the lower extremities, general muscular weakness so that the child is easily fatigued, loss of appetite, coated tongue, constipation, headache, muscular pains, and often cough from a slight bronchitis. These symptoms may depend upon many conditions other than malaria, even when they are seen in a malarial district. The only positive evidence of malaria in such cases is the presence of the malarial organisms in the blood. Even the enlarged spleen, anemia, and slight fever, which are often looked upon as diagnostic, may be present in cases of anemia with which malaria has nothing whatever to do.

**Diagnosis.**—The diagnosis of malaria rests upon the demonstration of the parasites in the blood. They will be found in nearly all the cases provided a careful



examination is made a few hours before the paroxysm, and also provided that no quinine has been administered. When their number is small they may be missed at the height of the fever, although they may readily be found just before the temperature begins to rise. Repeated examinations of the blood are sometimes necessary before the organisms can be demonstrated, particularly in chronic cases. The use of adrenalin has been shown to be of definite value in bringing out organisms into the circulating blood. In cases of failure to demonstrate the parasite in the blood, malaria can be suspected with a history of exposure in a district known to be malarial. The periodicity of the symptoms coupled with splenic enlargement is always suspicious. Particular importance is to be attached to the therapeutic test. Recent experience emphasizes more and more strongly the fact that quinine has very little influence upon fevers which are not malarial, and, conversely, that a fever immediately and permanently controlled by quinine is pretty certain to be malarial.

The fever and recurring chills of pyelitis are often mistaken for malaria. Many conditions accompanied by an enlarged spleen may be confounded with malaria. While malaria may be multiform in its manifestations, the physician can fall into no more serious error, even in a malarial district, than to regard all ailments with obscure or indefinite symptoms as malarial, neglecting careful physical and blood examinations, by which means alone an accurate diagnosis is reached.

**Prognosis.**—Although it is seldom fatal in itself, an attack of malaria in a young child may so undermine his constitution that he may succumb to some other acute disease. Cases are often difficult to cure while the patient remains in the malarial district, and when frequent re-infection occurs. In other circumstances and with proper treatment the prognosis of malaria is good.

**Treatment.**—*Prophylaxis.*—Besides the general measures proposed for the extermination of the mosquitoes concerned, emphasis should be laid upon the necessity, in the case of young children, of protecting them against the bites of mosquitoes in localities which are or which may possibly be malarial. For children who reside in a malarial district, the prolonged use of small doses (2 to 5 grains daily) of quinine is of great value in preventing attacks of malaria.

*Methods of Administration of Quinine.*—For infants our own preference is to give the sulphate or bisulphate in an aqueous solution, 2 or 5 grains to the teaspoonful, according to the age of the patient. Most infants take such a solution with less difficulty and vomit it less frequently than the combinations with the various vehicles supposed to cover its taste. If the quinine is given at night upon an empty stomach, vomiting seldom occurs. If repeated vomiting makes it impossible to give quinine by mouth it may be given hypodermically. For this purpose quinine and urea hydrochloride is perhaps the most satisfactory preparation, given in doses of from 2 to 5 grains. It is more or less irritating and there usually follows some induration at the site of the injection, which may last a long time. While the hypodermic use of quinine is sometimes invaluable it should not be employed in infants except in serious attacks and when the diagnosis has been established. The frequent repetition of the hypodermic injections should be avoided; in most cases, two or three good doses are sufficient, the effect being continued by quinine given by other methods. If there are gastric disturbances



that prevent adequate dosage by mouth, intravenous therapy is usually preferable to hypodermic.

For children from two to seven years old the taste of quinine must be concealed. An aqueous solution of the bisulphate may be mixed with the syrup of sarsaparilla, orange, or yerba santa; or the sulphate may be given in suspension in one of the same vehicles, the mixture being made just before the dose is taken; otherwise the partial solution of the drug will render the whole dose exceedingly bitter. For children over seven years old, the same methods of administration may usually be employed as in adults. It is preferable to give it in capsule form.

In a case with well-marked paroxysms the quinine should if possible be given in the interval, with the largest dose about four hours before the expected paroxysm. With infants this plan is sometimes impracticable, as frequent small doses are usually better borne by the stomach than a few large ones. In them also vomiting seems less likely to occur when quinine is given on an empty stomach. For this reason it is advantageous to give the drug at regular two- to three-hour intervals during the night, and omit all medication during the day.

*Dosage.*—Relatively much larger doses of quinine are required for young children than for adults. Except for its tendency to disturb the stomach, quinine is borne remarkably well by little patients. Generally too small doses are given. An infant of a year with a sharp attack of malarial fever will usually require from 8 to 12 grains of the sulphate (10 to 14 grains of bisulphate) daily. Occasionally we have found it necessary to give double the quantity referred to. It is useless to expect to control an acute attack of malaria by such doses as 1 grain three or four times a day. Children from five to ten years old require almost as large doses as do adults.

*Substitutes for Quinine.*—Many substitutes have been recommended, the most noteworthy being arsenical preparations, and, most recently, plasmochin. Cacodylates and arsphenamine preparations have some effect, but they are in no sense as specific as quinine. Plasmochin has attracted much attention because of the claim that it exercises a specific influence on the crescents of estivo-autumnal malaria. It may be of distinct value in public health campaigns, for by its action on the sexual forms of the parasite it limits the possibility of mosquitoes' being infected by man. However, on the whole, plasmochin is not the equal of quinine as an antimalarial drug and is more likely to cause poisoning than quinine. At the present time it cannot be recommended as a safe drug for routine use.

Chronic cases of malaria usually require iron, as secondary anemia is often severe in these. Other manifestations are to be treated symptomatically.

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## CHAPTER CXLVIII

### DISEASES CAUSED BY INFECTION WITH RICKETTSIAE

Among the diseases attributed to rickettsiae only two are seen in the United States, typhus fever and tick-bite fever. Both diseases are relatively rare in their severe forms, but undoubtedly *formes frustes* are not infrequent and usually remain unrecognized. Children with these mild infections may have little or no eruption and only mild constitutional symptoms. Slightly more severe infections may be considered mild attacks of typhoid and be reported as such.

Typhus may occur anywhere in the United States sporadically. Tick-bite fever is endemic not only in the Rocky Mountain states, but also along the Atlantic coast south of Delaware.

#### TYPHUS FEVER

Under ordinary conditions typhus fever is a disease of cities and is most frequently seen during cold weather. It is relatively rare among children in the United States. Two forms of the malady are seen in this country—Brill's disease, which is European or epidemic typhus fever modified by the environment which exists in America, and endemic American typhus or *tabardillo*.

**Etiology.**—Typhus is caused by the introduction into the body of the patient of an organism called *Rickettsia prowazeki*. This parasite has never been grown alone on artificial media, but grows well in tissue cultures and may be inoculated into rabbits and guinea-pigs with the production of a febrile disease characterized by hemorrhagic lymphadenitis and an inflammatory reaction in the animal's scrotum. The rickettsiae are very small pleomorphic bodies which stain with difficulty with the azure in Giemsa's mixture. They may be coccoid, diplococoid or bacilliform, or may assume forms which resemble diphtheroid organisms or chains of streptococci.

The organism is usually introduced into the human body by the body louse. The rat-flea may also transmit the organism and there is experimental evidence to show that the bedbug may serve as the vector.

**Pathology.**—Apart from congestion of the organs and occasional hemorrhages there is little to be found at autopsy which is characteristic of the disease. The spleen is, however, enlarged and soft. The microscope reveals the presence in the brain of the so-called typhus nodules, which are perivascular areas of infiltration with round cells. These nodules are found only in typhus and in tick-bite fever.

**Symptoms.**—The period of incubation is from seven to twenty-one days. A shorter incubation than seven days should suggest that the condition in question is not typhus. The usual incubation extends from twelve to fourteen days.

The onset is sudden with severe headache, chilliness and prostration, frequently



with vomiting. The fever ascends rapidly to 103° F. or over, and the temperature is maintained constantly without morning remissions.

Patients who are suffering from severe attacks of typhus become progressively worse as the disease runs its course. Prostration increases and there is nocturnal delirium. During the day when not delirious the child is stuporous and only vaguely conscious of his surroundings. On or about the fourth day the rash makes its appearance. It is morbilliform at first but rapidly becomes hemorrhagic. A second element in the eruption is a subcuticular mottling due to elements of the rash which lie deep below the surface of the skin. The eruption begins in the axillae and in severe cases spreads rapidly to involve the entire body except the face, which has a characteristic bloated appearance like the face of a habitual drunkard. Areas of gangrene, which may develop in the skin of adults, are not seen in children. The eruption has a predilection for extensor surfaces, pressure areas and the skin about joints. It involves the palms and soles.

Very mild infections may occur without any rash and it is not uncommon to see patients in whom the eruption has to be searched for and consists only of the subcutaneous mottling or in a few scattered macules which may or may not become hemorrhagic. The application of a tourniquet may render a fading rash visible. The eruption begins to fade about the tenth day of the disease and its disappearance is followed by desquamation, especially marked on the soles of the feet.

On the seventh to the ninth day the temperature often falls (pseudocrisis of typhus) only to rise again and maintain its level until the fifteenth day, when it terminates by crisis or by a rapid lysis. Convalescence is usually uneventful.

The blood picture is not constant. There is usually at the onset of the disease a polymorphonuclear leukocytosis, which may persist or be followed by leukopenia. The most striking feature is often an increase in the relative and absolute number of large mononuclears. Rickettsiae can sometimes be stained in the cytoplasm of these cells. The blood serum during typhus not infrequently gives a positive Wassermann reaction and the Widal is reported to be positive in a certain percentage of typhus patients. At any time after the second week of the illness the so-called *Weil-Felix reaction* makes its appearance and persists from six weeks to two months after convalescence. This reaction is the agglutination of cultures of *B. proteus* X19 or X2 by the serum of patients with typhus or tick-bite fever; it is specific when it occurs in dilutions of 1:80 or above. The diazo reaction is almost invariably given by the urine.

**Complications.**—Bronchitis is so constantly present as to be a part of the picture of the disease and bronchopneumonia may develop at any time during the course.

Myocarditis, as indicated by a rapid pulse and lengthening of the P-R interval, is regularly present and is apparently the result of the disease itself. The kidneys are rarely damaged by the malady and then only to the extent of a febrile albuminuria. Occasionally thrombosis of the veins has been described in children.

**Diagnosis.**—When typhus is fully developed, severe cases can hardly be mistaken for any other disease except tick-bite fever, but early in its course or in mild cases where the rash is scanty other conditions have to be ruled out. Typhoid



can be excluded by failure to recover *B. typhosus* from the blood or stools. The Weil-Felix reaction also distinguishes between the two maladies. Against typhoid is the history of an abrupt onset and the marked contraction of the pupils of typhus patients. The course of the disease and examination of the cerebrospinal fluid will rule out epidemic meningitis. Guinea-pigs inoculated with the blood of a patient with typhus fever regularly develop a febrile reaction.

Before the rash has become hemorrhagic it may be mistaken for the eruption of measles, but the march of the rash and the absence of Koplik's spots or coryza should serve to distinguish one from the other. A history of a previous attack of measles may also be of service in the diagnosis.

**Prognosis.**—As is the case with many of the diseases caused by filtrable viruses, such as yellow fever, the mortality among children with typhus fever is low. Before the age of fifteen years only from 2 to 5 per cent of the patients succumb, as contrasted with a mortality of from 30 to 40 per cent in patients over this age. This fact accounts for the enormous numbers of orphans after epidemics of typhus in the Near East and in Ireland. The adults have the disease and die; the children survive. One attack of typhus confers a lasting immunity against the disease, but gives no cross immunity against other rickettsial infections.

**Treatment.**—This is purely symptomatic. There is no specific treatment known against typhus fever.

### TICK-BITE FEVER

Tick-bite fever was until 1929 supposedly confined to Montana, Idaho, Colorado and California, where it was known as Rocky Mountain spotted fever. It is now known to be endemic from Delaware southward along the Atlantic coast as far as Texas. Furthermore, the condition is common in South Africa, and more careful search will undoubtedly demonstrate other localities to be affected.

The disease is supposed to result from infection by a rickettsia called *Derma-centroxenus rickettsii*, and immunologically the coastal organism is identical with that causing the Rocky Mountain disease. There is, however, some evidence that there may exist different strains of dermocentroxenus. The vector is, as far as is known, always a tick: in the western states *Dermacentor venustus*, in the east *Dermacentor variabilis* (the common wood or dog tick) and in Africa *Amblyomma hebraeum*. The infection is usually conveyed by the tick in the act of biting, but has been acquired through small abrasions or possibly through unbroken skin as the result of crushing between the fingers ticks picked from pet dogs.

Epidemiologically tick-bite fever differs from typhus in that it is a disease of rural districts and is rife in the spring and summer when ticks infest the fields and woodlots.

Clinically the malady can be distinguished from typhus if the incubation period and the march of the rash are known. The incubation is short—from two to five days, commonly three or four days. The eruption begins on the hands, arms, feet and legs and is centripetal in contrast to the spread of the rash of typhus, which is centrifugal, the extremities being the part of the body last involved.

In all other respects, including the agglutination reactions, the malady is identical with typhus. As in typhus, both mild and severe infections are met.



An absolute diagnosis can be made only by immunological methods. In guinea-pigs as in man an attack of tick-bite fever confers permanent immunity against a second attack, but gives no protection against inoculation with the virus of typhus fever. The converse is also true. Therefore, if a guinea-pig which has recovered from typhus is inoculated with a suspected blood and thereafter develops a febrile reaction, the virus is that of tick-bite fever. A guinea-pig recovered from tick-bite fever will give a febrile reaction to inoculation with the blood of



FIG. 201.—ERUPTION IN TICK-BITE FEVER.

a patient with typhus, but will remain unaffected by an inoculation with blood from a patient with tick-bite fever.

The prognosis for children is good. The mortality cannot be given in exact figures, but we know of no deaths in children.

There is no specific treatment. The United States Public Health Service produces a vaccine made of ground-up infected ticks which is valuable as a prophylactic. It is given in two doses of 2 c.c. each, subcutaneously, separated by an interval of five days. It is said to give almost complete immunity for one year. In most parts of the United States, however, the disease is so infrequent that such immunization is not justified.

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## CHAPTER CXLIX

### GLANDULAR FEVER

(PFEIFFER'S DISEASE; INFECTIOUS MONONUCLEOSIS)

Glandular fever is a communicable disease of unknown etiology characterized by fever, swelling and tenderness of the lymph nodes all over the body and a marked lymphocytic reaction in the blood. It is a benign affection; no complications or fatalities have been reported.

Glandular fever is met with at all ages; it occurs both sporadically and in epidemics. The incubation period varies from four days to two weeks but is constant for the same epidemic. The onset is usually sudden with general malaise, prostration and headache; sometimes there is a sore throat. The temperature rises to 102° or 103° F. Within two or three days enlargement of the lymph nodes is apparent. In some cases the cervical nodes are especially enlarged, but the enlargement is always general and usually affects all the nodes of the body to an equal extent. The nodes are distinctly tender. The spleen is often enlarged and sometimes the liver as well. There is no skin rash. The duration of the fever is rarely more than five days; the lymph nodes show their maximum enlargement at the time the fever is subsiding. During the ensuing week or two they gradually return to normal in size.

In the early stages of the disease there may be a leukocytosis of 12,000 to 15,000 with an increase in polymorphonuclear cells; in other instances there is a leukopenia. The characteristic feature of the blood picture is a relative and absolute increase in the mononuclear cells with the appearance of many immature abnormal forms. The red cells and platelets are not affected. This mononucleosis usually outlasts clinical recovery; it may persist in some degree for several months. The mononuclear cells are apparently lymphocytes rather than monocytes.

Glandular fever must be distinguished from acute leukemias and from other specific infectious diseases in which a similar lymphocytic response may be encountered. Only the sporadic cases are likely to be confused with leukemia. The proportion of lymphocytes is rarely as high in glandular fever as in leukemia, nor are young forms as numerous. Anemia, reduction of the platelets and hemorrhagic manifestations occur in leukemia but not in glandular fever.

A lymphocytosis is likely to be found in pertussis, rubella, influenza, dengue fever and a few other infections. Rubella and pertussis should cause no confusion. We have, however, seen during the course of an influenza epidemic in Baltimore in 1930 a number of cases in children which were clinically indistinguishable from glandular fever. The tendency of young subjects to respond to infections in general with striking enlargement of the lymph nodes and a lymphocytic blood picture has been commented on elsewhere, and adds to the difficulties of diagnosis.



Many writers have questioned the existence of glandular fever as a specific infection. It may well be that a number of different agents have been responsible for the various epidemics that have been described. This view is supported by the variation seen in the blood picture and the incubation period in individual epidemics. On the other hand, the recent discovery by Paul and Bunnell that heterophile antibody is consistently high in this syndrome—a finding that has been confirmed by subsequent workers—provides ample justification for regarding this disease as a distinct entity.

During the acute stage of infectious mononucleosis the blood serum develops a relatively high titer of agglutinins for sheep erythrocytes (heterophile antibody). Normal sera agglutinate sheep cells at a dilution of 1:2, 1:4, or sometimes at 1:8; in response to an injection of horse serum, the titer may rise to 1:32 or even 1:64; but in the period of active mononucleosis of glandular fever the titer is almost invariably higher than 1:64. This phenomenon has come to play an important part in differential diagnosis; its specificity, however, is not absolute, for it occurs in serum disease as well as in glandular fever.

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## SECTION XX

### MISCELLANEOUS DISEASES

#### CHAPTER CL

#### DISEASES OF ABNORMAL LIPOID METABOLISM

There is a group of diseases of obscure origin which possess in common the characteristic that accumulations of large lipoid-containing cells occur in various parts of the body, these cells originating from the reticulo-endothelial system. Included in this group are *Gaucher's disease*, *lipoid histiocytosis* (Niemann-Pick disease) and the various forms of *xanthomatosis*. The term "lipoidosis" has been applied to these conditions. However, it is by no means clear that they are etiologically related. The grouping is one of convenience only.

#### GAUCHER'S DISEASE

Gaucher's disease (splenomegaly of the Gaucher type) is a relatively rare disease, which is familial but not hereditary. It is characterized by the accumulation of large cells in the spleen, the liver, lymph nodes, the bone marrow and sometimes in other organs. The disease is a generalized one.

It usually develops insidiously during the first decade; it is rarely seen in early infancy. The most conspicuous clinical feature is the great enlargement of the spleen, which is slowly progressive; it may eventually nearly fill the abdomen. It is firm, smooth, usually with rounded edges, but not tender. While never reaching the proportions of the spleen, the liver may be considerably increased in size; it is also smooth. The blood shows a secondary anemia with a leukopenia ranging between 3000 and 6000, and an essentially normal differential count. The platelets are usually reduced. The anemia may be very severe, generally as a result of hemorrhages. Associated with this is a peculiar brown discoloration of the skin, particularly of the face. In some instances there is a yellowish wedge-shaped thickening of the conjunctiva on either side of the cornea. The superficial lymph nodes may be palpable, but are usually not materially increased in size. The disease runs a very chronic course. The general health may be fair for many years. The splenic and hepatic enlargements may cause abdominal enlargement and even pain, but it is rare for jaundice or ascites to develop. Eventually hemorrhages may occur from slight traumata or spontaneous bleeding, usually from the mucous membranes. Changes in the bones have been described in a number of late cases; the long bones are most frequently affected, particularly the femur. Irregular areas of rarefaction are found. The contour of the bone may be altered or there may be pathological fractures. Involvement of the nervous system has been described.



In most cases death occurs from some intercurrent disease before these generalized manifestations have become conspicuous.

Within the last few years a number of reports have appeared describing an *infantile type* of Gaucher's disease which differs in some respects from the more usual juvenile or adolescent form of the disease. The onset is so early as to suggest a congenital origin; it has been detected at the age of one month. The course is a very rapid one, and death occurs within a few months. Anemia, hemorrhagic phenomena and pigmentation of the skin are wanting. Nervous symptoms and a marked cachexia develop early. Failure to gain weight or loss of weight may first attract attention. The enlarged spleen and moderately enlarged liver are present. Soon there develops mental deterioration with retraction of the head, opisthotonos, increased reflexes and spasticity of the limbs. This type exhibits the typical Gaucher cells in the spleen, liver, lymph nodes and bone marrow. The cerebral lesions, however, are quite different. There is a progressive cortical degeneration, the nerve cells showing changes that closely resemble amaurotic family idiocy.

The combination of cachexia, enlargement of the spleen and liver and cerebral degenerative symptoms should make the recognition of the infantile type of Gaucher's disease easy; only Niemann-Pick disease gives similar symptoms. The juvenile or adolescent form may be more difficult to recognize. This must be distinguished from the other causes of splenomegaly, particularly from Banti's disease. Excision of a lymph node occasionally makes an absolute diagnosis possible. The diagnosis has been made several times by splenic puncture, which will regularly reveal the typical Gaucher cells. Most cases, however, have been recognized only after splenectomy or at autopsy.

The pathological findings are distinctive. The spleen, liver, lymph nodes, bone marrow and sometimes other organs are invaded by characteristic large cells with one or more small nuclei and with a finely granular cytoplasm showing radial striations. These cells are rich in lipid material, but this does not stain with the ordinary stains. The cells contain no vacuoles, in contrast to the findings in Niemann-Pick disease. The lipid material has been identified by Lieb as the cerebroside *kerasin*, an observation confirmed by others.

The nature of Gaucher's disease is altogether obscure. Although Gaucher originally regarded it as a new growth, this view has now been largely abandoned. It seems more probable that it is due to some congenital anomaly affecting the lipid metabolism. Changes in the blood lipoids, however, have not been found.

Treatment is purely symptomatic. In the juvenile or adolescent cases removal of the spleen may cause temporary relief, but the fatal outcome is at best only delayed.

## NIEMANN-PICK DISEASE

(LIPOID HISTIOCYTOSIS; SPLENOMEGALY OF THE NIEMANN-PICK TYPE)

This condition was at first confounded with Gaucher's disease, although it now appears to be an entirely distinct entity. It is familial but not hereditary and is confined almost entirely to the Jewish race; most of the reported cases have been in females.



The disease begins in infancy and is usually fatal within a few months, death occurring before the end of the second year. Enlargement of the spleen and liver, and anemia occur rapidly; there is general wasting and in many instances degenerative changes in the central nervous system indistinguishable from those found in amaurotic family idiocy. In several instances the typical changes in the retina have been observed. It is thus apparent that Niemann-Pick disease resembles closely the infantile type of Gaucher's disease, but has little in common with the juvenile type. The differentiation from Gaucher's disease can be made with certainty only by splenectomy, by splenic puncture or perhaps by biopsy on a lymph node, which reveals the characteristic cells. In Niemann-Pick disease, as in Gaucher's disease, there are found accumulations of large cells which originate from the reticulo-endothelial system. The cells differ, however, in their distribution and their histological and chemical characteristics. Although they are most numerous in the spleen, liver, lymph nodes and bone marrow they may occur in almost any organ of the body and even in the blood. The Niemann-Pick cells contain large vacuoles in which lipid material can be readily stained. Similarly staining vacuoles may occur in the parenchymatous cells of various organs. They have been observed in the monocytes and lymphocytes of the blood. An elevation of the blood lipids has been found in some cases.

The nature of the lipid material in the phagocytic cells is still a matter of some dispute; it has been variously reported as lecithin, cephalin and a mixture of cholesterol and cholesterol esters. The most recent work indicates that it is the phospholipid sphingomyelin which is not properly utilized in the synthesis of cerebrosides.

### XANTHOMATOSIS

Benign xanthomatous tumors are common in adults, although infrequent in children. These occur usually in the skin, sometimes in the internal organs; they are yellow in color and are characterized by the presence of large mononuclear cells containing vacuoles in which lipid can be stained. This material is rich in cholesterol. Such tumors are frequently found in the skin; about the eyelids they constitute the familiar xanthelasma. They often occur in association with jaundice and pregnancy. In those cases of diabetes mellitus with lipemia, xanthoma cells are found in the spleen, lymph nodes, liver, bone marrow and elsewhere. Histologically these cells are indistinguishable from those found in Niemann-Pick disease. When the diabetes is under control and lipemia has disappeared these cells also tend to disappear.

A rare and less benign form of xanthomatosis occurs in childhood and goes by the name of Schüller-Christian's disease, or xanthomatosis of the Schüller-Christian type. It is characterized by the appearance of xanthomatous tumors in the flat bones, usually the bones of the skull. These usually involve the base of the skull, leading to symptoms of hypopituitarism and diabetes insipidus. The orbit is often involved, causing exophthalmos. The triad of symptoms: defects in membranous bones, diabetes insipidus and exophthalmos was emphasized by Christian, who ascribed the condition to dyspituitarism.



The clinical picture is a definite one. The disease has only once been reported in more than one member of a family. It shows no racial or sex predisposition. The onset is insidious, usually between the second and sixth year. Often it follows some contagious disease. It is noticed that the child is unusually irritable, then some characteristic manifestation develops such as exophthalmos or diabetes insipidus. In some instances involvement of the mandible or maxilla has caused swelling of the gums and falling out of the teeth. A persistent aural discharge may result from involvement of the mastoid.

When an x-ray of the skull is taken the bony defects stand out sharply as shown in the accompanying figure (Fig. 203). The changes are always most con-



FIG. 202.—EXOPHTHALMOS AND ERUPTION IN XANTHOMATOSIS.

spicuous in the skull, but other flat bones may be involved—the pelvis, scapula and rarely the long bones. Pain may result from the bone lesions. Occasionally there is a low grade fever. There may be a secondary anemia with yellowish discoloration of the skin. In a small proportion of the cases there have been cutaneous xanthomata. The following is a typical history:

(H.L.H. 2180). The onset was at two and one-half years of age with bronchitis and cervical adenitis which persisted. The child developed swellings about the head, varying in size from time to time. He began to have exophthalmos of the left eye, which steadily increased despite radium therapy. X-rays of the head showed areas of bone destruction. At the age of five the left eye was enucleated. Exophthalmos had then appeared on the right. The teeth were in wretched condition. Tumor-like swellings continued to appear and disappear about the head. A papular, vesicle-like eruption on the chest and abdomen was noted at various times. The liver was enlarged. X-rays of the chest showed fibrosis with a miliary appearance.

The last note states that the patient is now twenty years old. He is a symmetrical dwarf 56 inches in height, with a soprano voice, scanty hair, transverse crines and a female distribution of fat. X-rays show minimal changes in the skull. The lungs are negative. His general health is excellent (Fig. 204).



The disease is very chronic and is characterized by spontaneous remissions in all the symptoms. In the more severe and prolonged cases further evidence of hypophyseal disease may develop in the form of dwarfism or the Fröhlich syndrome. When the bony lesions are widespread, walking may be difficult and the patient become bedridden.

The ultimate prognosis is indefinite; the condition may last for years, but many of these patients fall a prey to some intercurrent infection.

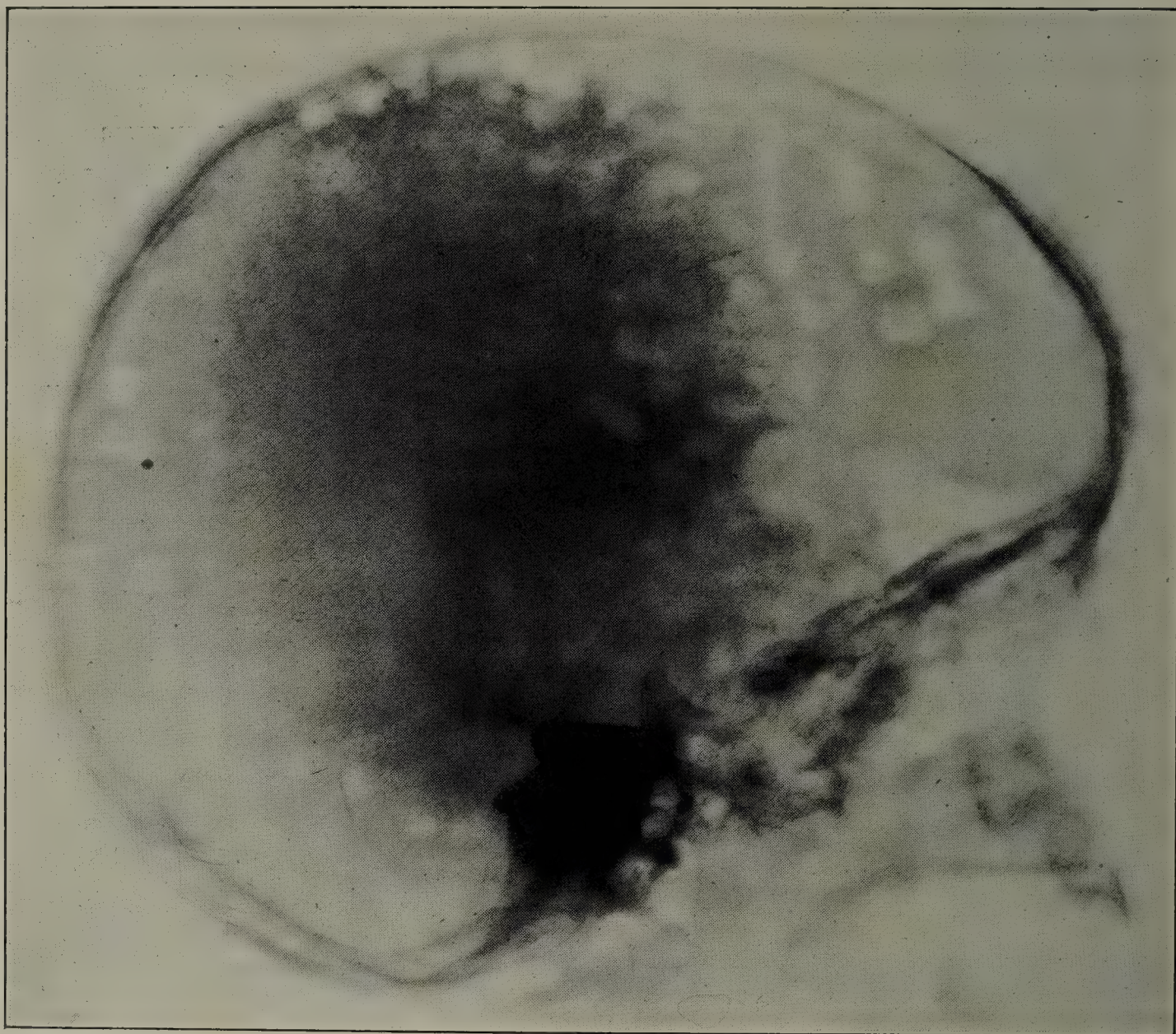


FIG. 203.—ROENTGENOGRAM OF SKULL IN XANTHOMATOSIS, SHOWING MULTIPLE PUNCHED-OUT AREAS OF RAREFACTION.

The lesions at autopsy are widespread. The bony defects are found replaced by rubbery, yellowish masses consisting largely of xanthoma cells. In very old lesions there may be fibrosis. The condition is not confined to the bones; there is a diffuse xanthomatosis of all the organs.

The disease can be influenced to some extent by treatment. Sosman has shown that x-ray therapy will at times cause the defects in the skull to disappear, with corresponding symptomatic improvement. The benefit is only temporary, for other lesions continue to appear. Rowland's observations indicate that something can be accomplished by a diet low in fat and cholesterol. The blood lipoids are not always elevated, but in many instances the cholesterol in particular is greatly increased and can be diminished by suitable diet.



The origin of the disease and its relation to the other forms of lipoidosis are equally obscure. By some it is regarded as a skeletal form of Niemann-Pick disease. Although the xanthoma cells cannot be distinguished from the cells of Niemann-Pick disease by histological means, it is not certain that they contain

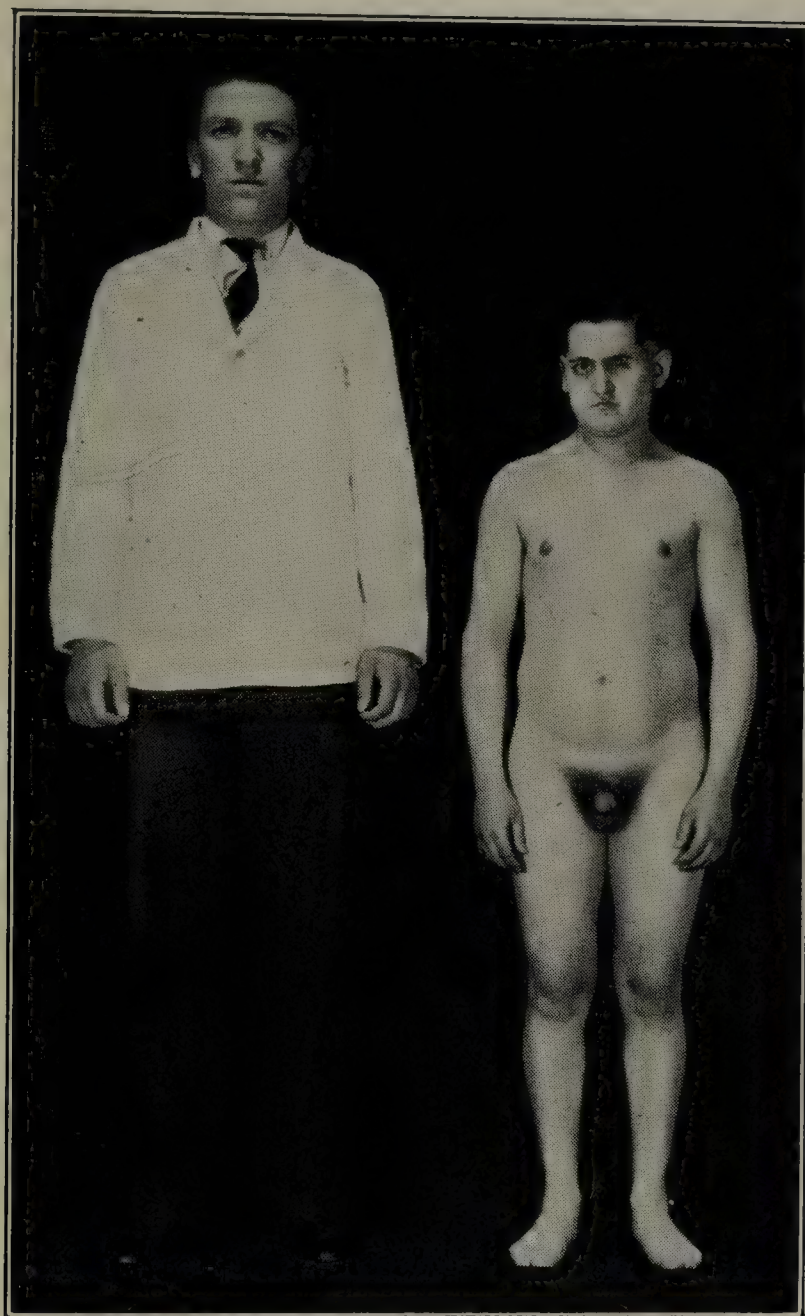


FIG. 204.—DWARFISM IN XANTHOMATOSIS.

identical lipoids. Both contain phosphatides and cholesterol, but the phosphatide content of the cells in Niemann-Pick disease is emphasized and the cholesterol content in xanthomatosis. Further observations are required to settle this point, but the difference in clinical features suggests that they are not identical.

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## CHAPTER CLI

### AMYLOIDOSIS

Amyloid is a complex protein derivative of undetermined chemical structure. It was formerly believed to be chondroitin sulphuric acid, but this has been disproven. It occurs in various organs as an intercellular deposit, and is found within the cells of the reticulo-endothelial system. Whether it is formed within these cells or phagocytosed by them is not certain. Its presence in the intercellular spaces leads to pressure atrophy of the parenchymal cells of the various organs.

Amyloid deposition is most often seen in children after long-continued suppurations, such as chronic staphylococcic osteomyelitis, bone tuberculosis with discharging sinuses, advanced pulmonary tuberculosis, empyema, and syphilis. Apparently it is caused by the products of cellular necrosis rather than by a specific type of infection. Experimentally it has been produced in animals by the prolonged action of the staphylococcus, the repeated injection of diphtheria toxin and of other foreign proteins, such as sodium caseinate and egg albumin. The feeding of casein will cause it in mice.

**Pathology.**—The spleen, liver and kidneys are perhaps the commonest sites for amyloid deposition, but it occurs in every other organ at times. The liver is generally very much enlarged; in extreme cases a weight of six or seven pounds may be reached. It is of a uniform, glistening, waxy appearance, very firm and hard. The spleen, likewise, may be very large. Sometimes the amyloid is diffusely infiltrated throughout the organ, but at other times it is confined to the malpighian bodies, causing the characteristic “sago spleen.” In the kidney the amyloid is laid down about the capillaries of the glomeruli, and in the walls of arterioles and straight conducting tubules. The ileum is the part of the intestine most affected. The process begins in the walls of the arterioles and capillaries, particularly of the villi, and later involves the vessels of the submucosa; subsequently the epithelium may be affected. When a solution of iodine is applied to the cut surface of an organ, the amyloid is stained mahogany-brown. It may also be selectively stained with Congo red and methyl violet.

**Clinical Signs.**—Amyloidosis is most frequently encountered in orthopedic hospitals in children who have had chronic bone infections for a number of years. The course is generally progressively but slowly downward, until extreme cachexia leads to death, or some acute terminal infection sets in. Amyloid degeneration produces no definite symptoms. The spleen usually becomes enlarged early in the course of the disease. The liver becomes progressively larger; it is firm and not tender. The surface is smooth and the edges are usually rounded. Eventually the child may present a picture of extreme emaciation, except for an enormous abdomen nearly filled by a huge liver and spleen. Jaundice does not occur. Ascites and evidences of collateral circulation are rarely present, except in cases in which the



liver is very large. Edema of the lower extremities may result from pressure of the large liver upon the vena cava. Albuminuria may occur early in the disease before the enlargement of the spleen and liver is detected. Sometimes, however, it is not present even in fairly advanced cases. Phenolsulphonephthalein is normally excreted; the nonprotein nitrogen of the blood is not increased and the blood pressure is not elevated. Anasarca is not usually encountered. As a result of intestinal involvement, diarrhea may occur, but is by no means constant. Secondary anemia is usually present. There is sometimes a peculiar waxy cachexia, which is seen in no other condition but resembles somewhat that belonging to malignant diseases. The face has the appearance of alabaster and the skin has a singular translucency, due to amyloid deposition in the skin. The fingers may be clubbed.

**Diagnosis.**—The condition can readily be suspected when a markedly enlarged liver and spleen are found. In early cases the diagnosis is difficult. When albuminuria occurs as one of the first signs, it is necessary to differentiate amyloid kidney from nephrosis and other causes of albuminuria. The Bennhold Congo red test will distinguish amyloidosis from all other conditions. When Congo red is injected intravenously into normal individuals it is excreted very slowly through the liver and 70 to 90 per cent remains in the blood stream at the end of an hour. Amyloid, however, takes up the dye rapidly, causing it to disappear from the blood almost completely at the end of one hour. It is not excreted in the urine. In "lipoid" nephrosis there is also a rapid decrease of the Congo red in the blood, but in this case it is found to be excreted in the urine. In amyloidosis, as in nephrosis, there is a reversal of the albumin-globulin ratio of the blood serum with a relative increase of globulin. In the former condition a large proportion of the urinary protein consists of globulin.

**Prognosis and Treatment.**—Amyloid changes usually take place slowly, the whole course of the disease being marked by years, the patient dying from asthenia or from some acute intercurrent disease. As a rule cases go on steadily from bad to worse; but sometimes, after the disease has reached a certain point, the condition remains stationary for a long time. A few cases of cure are reported after the excision of the diseased joints upon which the amyloid degeneration depended. Recently Whitbeck has reported cures in a small series of patients to whom he fed liver. Experimentally in mice the feeding of liver, of beef heart, or of a fat-cholesterol diet is said to retard the development of amyloid.

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## CHAPTER CLII

### ACRODYNIA

(ERYTHREDEMA; DERMATOPOLYNEURITIS; SWIFT'S DISEASE; PINK DISEASE)

This disease has attracted much attention in the last few years. Among the earliest cases recorded were a number from Australia and it is known that the disease was recognized there more than thirty years ago. While it is perhaps true that acrodynia has increased considerably in recent years, it cannot be definitely said that it is a new disease. Nomenclature of disease is unsatisfactory unless it is possible to base this upon some distinguishing etiological or pathological feature. Both are lacking here and it is, therefore, perhaps justifiable for the present to designate the condition according to one of its most striking clinical manifestations.

**Etiology.**—Numerous causes have been advanced for acrodynia. It has been suggested that it is a sequel of epidemic influenza. It was, however, described in Australia before the pandemic of 1918 and it has appeared in children born since that time. No specific bacterium or virus has been connected with it. On account of the similarity of some of the symptoms to pellagra, acrodynia has been referred to some deficiency in the diet. In most of the cases studied, judged according to accepted standards, the diet has been excellent. It must be confessed that, at the present time, the etiology is entirely obscure.

**Pathology.**—But few autopsies have been recorded and the reports of most have been indefinite and fragmentary. The changes in the skin are striking. There is a great hyperplasia of the epidermis with most extensive hyperkeratosis. Contrary to what one would expect from the gross appearance of the skin in life, there is little if any edema of the corium. There is no perivascular inflammatory reaction and only slight perivascular edema. There is some atrophy of the subcutaneous adipose tissue and moderate pigmentation of the rete with hypertrophy and dilatation of the sweat glands. A number of observers have described changes in the brain, cord, dorsal root ganglia and peripheral nerves. Wyllie and Stern, in a study of 7 cases, found an increase in the small cells of the cord in 7, axonal chromatolysis of the anterior horn cells in 5, and degeneration of myelin in the peripheral nerves or vagus in 5. Orton and Bender found chromatolysis of recent origin throughout the central nervous system; the lateral horns of the spinal cord showed older, and apparently specific lesions—marked cell destruction, with the cells diminished in number and involved in the various stages of fragmentation; gliosis in these areas; and numerous small hemorrhages. These authors compare the lesions in the lateral horns in acrodynia to those found in the anterior horns in acute anterior poliomyelitis. The changes in the nervous system do not appear to be constant. In a recent case of ours which was carefully studied by MacCallum the peripheral nerves and the cord were found to be normal.



**Symptoms.**—Acrodynia attacks children between the ages of four months and three and one-half years. A few cases in older patients have been reported but beyond seven years the condition is practically unknown.

The symptoms develop insidiously. There is often a history of indisposition due to rhinopharyngitis or bronchitis or some digestive disturbance. Some weeks thereafter it is noticed that the child is apathetic and irritable when disturbed. He sleeps badly. With the appearance of these and other symptoms the eruption is seen. It not infrequently begins as a diffuse erythema involving the trunk and extremities, which becomes more marked on the hands and feet and finally is limited almost entirely to these. What remains on the body is only a miliary eruption with small pinkish or reddish papules. There is profuse generalized sweating which drenches the child and makes the changing of clothes necessary many times a day. The characteristic eruption which makes recognition of acrodynia usually easy is confined to the hands and feet. These appear swollen, especially the fingers and toes. There is a symmetrical discoloration of the hands and feet, the color being a dusky pink. The eruption gradually fades into normal skin as it approaches the wrists and ankles. There are sometimes found some scattered papules of deeper color upon the hands and feet.

Desquamation is usually marked. It occurs on the palms and soles in small flakes or there may be exfoliation of quite large pieces of epidermis.

The hands and feet are cold. Ulcers may be found between the fingers or on any part of the hands and feet, apparently resulting from traumatism, for there is great pain and discomfort. The children tear at their hands and feet, rub them together, pull at their fingers and toes or bite them. Owing to constant moisture the skin is often sodden. Extensive injury is at times done. We have even seen gangrene of the toes and half of one foot. Children who are old enough tell of the extreme itching and pain which they compare to burning by fire. The finger- and toenails not infrequently fall off.

The cheeks and nose are sometimes pink. The children rub their faces and they often assume a posture on their knees and elbows with their faces buried in the pillows. This position is assumed partly to protect their eyes, for photophobia is nearly always present. No changes in the eyes can be seen to account for this symptom.

Anorexia is constant. For weeks an insufficient quantity of food is taken and this results in considerable emaciation and weakness, so that the muscles become soft. Thirst is often excessive. Gastro-intestinal symptoms are not marked. Diarrhea is uncommon. There is often marked salivation and ulceration of the gums, tongue and interior of the cheeks. There may be necrosis of the jaw. The teeth have been described as falling out even in the absence of obvious disease of the gums. The hair falls out or is pulled out so that some children are nearly bald.

There is frequently a leukocytosis of from 12,000 to 15,000 cells without any distinct alteration in the proportion of leukocytes. Anemia is not constant. In some instances the blood pressure is increased, and a high pulse rate is the rule. The urine is normal or contains a slight trace of albumin. There is no fever unless complications, such as pyelitis, which is believed to be relatively common, are present.



No less impressive than the cutaneous symptoms are those that relate to the nervous system. Insomnia has been spoken of. It is persistent and trying. Irritability is the rule. The children give the impression of abject misery. They will not smile or play. They sit in bed with a distressed expression, pulling, tearing or biting at their hands and feet or rubbing their faces in the bed. Writhing movements are sometimes very characteristic, due to the extreme itching. The superficial and tendon reflexes are obtained with difficulty. There seems to be some anesthesia of the skin of the extremities.

The course of the disease is measured by months, sometimes by a year or two. There are remissions and exacerbations in the severity of the symptoms but usually these are constantly present although in varying intensity. It is a trying disease for all concerned, patients, parents and physician.

**Prognosis.**—This is good unless complications such as pneumonia occur; then owing to the enfeebled condition of the child the outlook is less favorable than under normal conditions. In comparison to the number of cases reported, and the severity of the disease in many instances, the number of fatalities has been low. Recovery is usually complete. There are no sequelae.

**Treatment.**—This is purely symptomatic. Large amounts of sedatives are often required. Relief from the itching is sometimes obtained by placing the extremities in water. If the anorexia is so pronounced that a very insufficient diet is taken, and if there is great loss of flesh and strength, feeding by gavage should be resorted to.

Rodda has reported speedy improvement and rapid recovery in a number of cases following tonsillectomy, in spite of the fact that the tonsils and lymphoid structures of the rhinopharynx did not appear diseased.

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## CHAPTER CLIII

### LEAD POISONING

This is by no means a rare occurrence in children; some 36 cases have been recognized at the Harriet Lane Home. The variety of ways in which lead can be acquired is very great. Although it may be absorbed through the skin or inhaled, ingestion is the usual route. Perverted appetite is nearly always the cause; this is most commonly seen between the ages of two and five years. These children are apt to put anything into their mouths; they gnaw the paint from their cribs, their toys or various articles of furniture. Lead poisoning may occur even in young infants; we have seen it result from the use of a lead nipple shield and from a lead acetate ointment applied to the mother's breast. In Japan a face powder containing lead has caused a great many cases. In Baltimore an epidemic was recently observed in which poisoning resulted from the use of storage battery cases as fuel.

Acute lead poisoning due to the sudden ingestion of a large quantity of lead is almost never seen. Nearly always the lead is taken in in small quantities over a long period of time; many days or weeks may elapse before the symptoms develop. In children such classical manifestations as lead colic and wrist drop are rare. The disease usually begins insidiously with vague constitutional symptoms—pallor, listlessness, anorexia, constipation, vomiting and perhaps vague pains in the abdomen or elsewhere. Many cases fail to be recognized during this stage of the disease. It is characteristic of childhood that the central nervous system is particularly vulnerable. Encephalitis occurs early and with great frequency, and as a rule it is for cerebral symptoms that medical advice is first sought. These may come on a variable length of time after the prodromal symptoms have been noted, or may be the first manifestations. There may be headache, delirium, drowsiness or coma, but convulsions are usually the most conspicuous feature. They are very severe, often occurring in groups, and are exceedingly difficult to control with ordinary sedatives; in many cases death alone stops the constant jerking and irregular respirations. The blood pressure is frequently elevated in the acute stage of lead encephalitis.

Other nervous symptoms may be present. The rigidity may simulate meningitis; there may be automatic movements. Paralysis of the extra-ocular muscles may result in strabismus or ptosis. Peripheral neuritis affecting the extremities is occasionally met with; it was observed in 5 out of 36 cases seen in Baltimore. In one of these the paralysis was widespread and accompanied by sensory loss; this last, however, is rare. Paralysis of the lower extremity is much more common than wrist drop.

Fever is not a part of the picture of lead poisoning. It may occur as a terminal phenomenon, or an acute exacerbation of lead poisoning may occur with a febrile



attack caused by some infection. A secondary anemia due to increased blood destruction is characteristic. This is usually moderate but the hemoglobin may be as low as 20 per cent. Rarely, there may be visible jaundice. Immature red cells of all kinds are found, but punctate basophilia is especially conspicuous, occurring in over three-fourths of the cases. There are no characteristic changes in the leukocytes. The cerebrospinal fluid is under increased pressure; it is clear and usually shows some increase in lymphocytes. The average has in our experience been about 30 to 40 cells, but from 5 to 100 cells may be present. It is characteristic that the globulin content is out of all proportion to the cell count; a heavy

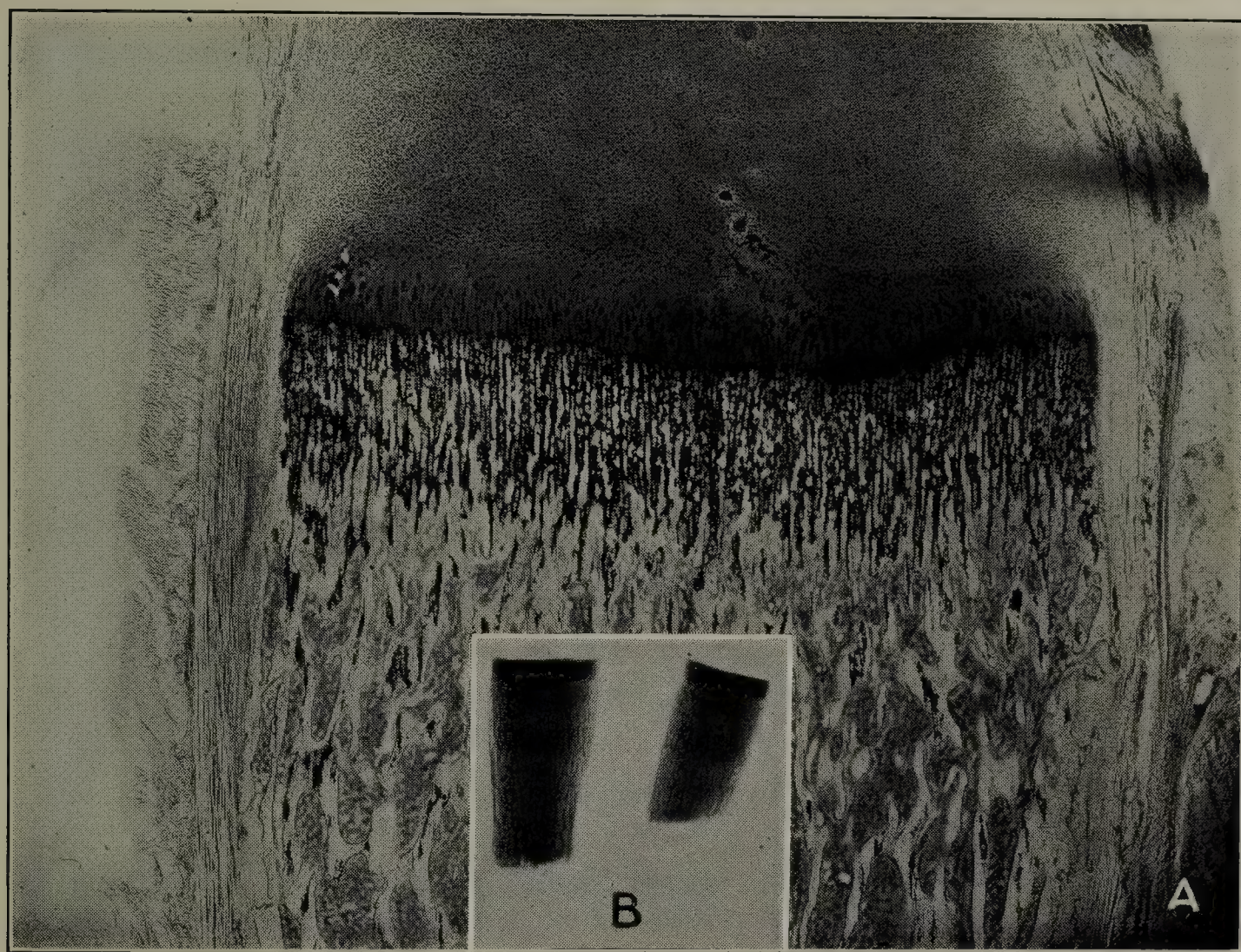


FIG. 205.—TRABECULAR CHANGES IN A RIB IN LEAD POISONING, SHOWING INCREASE IN DENSITY AND THICKNESS OF ZONE OF PREPARATORY CALCIFICATION.

precipitate may be obtained, although there is only a slight increase in cells or none at all.

The diagnosis is not difficult if the condition is kept in mind. The demonstration of lead in the excreta is of course conclusive evidence, but this aid is not generally available and may give negative results. In some instances a lead line is present in the gums. The eyegrounds may give helpful information; optic neuritis is often present and there may be retinal hemorrhages. Probably the most valuable confirmatory evidence can be obtained from an x-ray of bones. Park, Caffey and others have called attention to the increased trabeculation occurring at the ends of the long bones, which reveals itself as a zone of increased density beneath the epiphyseal line. The width of this dense shadow is a measure of the growth that has taken place since the onset of the poisoning.

In our experience lead poisoning has most frequently been mistaken for tuber-



culous meningitis. This mistake is an easy one to make if there happens to be a positive tuberculin reaction. We know of an instance in which a cerebral operation was undertaken with a mistaken diagnosis of cerebral tumor. Lead poisoning should be kept in mind in any case of obscure convulsions and one should inquire carefully into the history for a possible source of lead, look for a lead line, for punctate basophilia in the blood smear, and for the characteristic x-ray changes.

The prognosis in these cases is very grave. Of 20 patients with lead encephalitis and convulsions seen in the Harriet Lane Home, 13 died, 2 were left hopeless idiots, 3 are mentally retarded, 1 is mentally normal but shows ataxia and only 1 made a complete recovery.

The treatment is unsatisfactory at best. The immediate problem is usually to relieve the convulsions, which are thought to be due to cerebral edema. The ordinary sedatives are not very effectual, and in many instances a general anesthetic is required. The repeated intramuscular injection of a 25 per cent solution of crystalline magnesium sulphate is sometimes quite helpful. The dose is 0.2 gram of the salt per kilogram of body weight and may be repeated every three or four hours. Lumbar puncture may bring some relief, but it is unwise to withdraw much fluid.

The subject with lead poisoning contains most of the lead in the bones; that portion exhibiting the dense shadow is richest in lead. In the bones lead is stored as lead phosphate—a form that is comparatively inert. It has been shown that acidosis tends to remove lead from the bones and, with the entrance of lead into the blood stream, acute symptoms appear; this not infrequently happens in an acute infection. Conversely, it would seem logical to treat acute symptoms with alkali therapy in the hope of driving lead from the blood back to the bones. Alkaline phosphate, given by mouth, would seem to be the best preparation to use, but it must be employed cautiously, since in excess it may lead to tetany. It is possible that vitamin D may be of help, particularly if the blood phosphate is at all low. Elevation of the blood phosphate tends to favor the deposition of lead in the bones.

After an acute attack has subsided two problems remain—that of removal of lead from the environment and the possible “deleading” of the patient. The first of these may be a very difficult matter. Unquestionably many of our fatalities were due to inability to control the child at home. Such children would often return, months after an apparent cure, with a new attack of encephalitis; this might recur several times until eventually a fatal attack occurred. On the other hand the few favorable results were in cases where lead was easily eliminated from the environment. The question of deleading the patient is still a disputed one. Certainly this should not be done by producing an acidosis, as was once recommended; such therapy may bring on fresh cerebral symptoms. If the lead is left in place it remains a menace, for each new infection may bring on an exacerbation. Hunter and Aub have shown that a large part of the lead can be removed from the body by means of parathyroid hormone; moreover, the lead does not produce symptoms on its way out. This is a valuable therapeutic measure, but is not always successful, for a certain number of normal individuals are refractory to the parathyroid hormone.



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